APPENDICES

1. **Feedstock Description Report, Task A1**
2. **Trip Reports**
3. **Cellulase Enzyme Dosage Study**
4. **Process Flow Diagrams**
5. **Equipment List**
6. **Waste Water Report**
7. **Proforma and Sensitivity Analysis**

Appendix 1

Corporate Office
200 W. Douglas, Suite #820
Wichita, KS 67202-3008
(316) 269-4310
Fax (316) 269-4008
Email: hipc@aol.com

HIGH PLAINS CORPORATION

York Ethanol Facility
1414 County Road O
York, NE 68467-9534
(402) 362-2285
Fax (402) 362-7041
Email: highplains@navix.net

February 1, 2000

TO: Fran Ferraro, Merrick & Company

CC: Greg Heuer, Chris Standlee

Report, Task A1, Feedstock Description

Project No. 19013442 Building a Bridge to the Corn Ethanol Industry

This report summarizes the results of research conducted to 1) determine the availability of corn stover, and 2) evaluate the spent distiller's grains (DDG), for conversion to ethanol at High Plains Corporation's York, Nebraska Ethanol Facility. References are cited where appropriate.

CORN STOVER

From consultation and literature available, the best economic area of collection was assumed to be within close proximity to the plant operations. For practical application, including primarily ease-of-access to major highways (Highways 81 and 34 and Interstate 80), this report covers a five-county area centered around York County. The Ethanol Facility is located on Highway 34 approximately 3 miles east of the interchange with Highway 81 and 7 miles north of Interstate 80. This area includes irregular boundaries, but will represent an approximately 70-mile maximum transportation route from field to collection warehouse to plant site.

In all cases, the most conservative data or estimates were used. The following table summarizes the tons of stover that could reasonably be collected, stored, processed and transported to the York facility. The 1997 – 1998 *Nebraska Agricultural Statistics* report[1] on "Corn For Grain" acres harvested for the crop years 1995, 1996, and 1997, revealed that 1995 resulted in the lowest acres (and yield). The University of

Nebraska has reported[2] on collectible corn residue for 25 counties including the 5 counties of interest in this report. Their data included low, high, and "best estimates", and provided for exclusion of Soil Conservation Acres. This report used the lowest reported data less the tons of Soil Conservation residue.

High Plains Corporation (HIPC) has received privileged information indicating that 60% removal of stover from fields is both economically and practically viable using a proprietary system of custom harvesting, baling, storage and transportation[3]. Assuming that 50% of those producers with stover available will contract to participate in a collection process, then 30% of the collectible stover would be available for conversion. It has been variously reported that up to 3.7 tons per acre of stover is available[3]. Ranges of reporting could result from the inclusion or exclusion or the cobs and shucks with the stalks (Iowa State University has reported[4] that cobs and shucks make up 1.0 tons per acre). The table also indicates the resulting tons of stover if 30% of the available corn-growing acreage participated and 2.0 tons per acre can be harvested (a randomly selected, conservative number that approximates a value provided by the proprietary custom harvester noted above). This comparison provides a range that may be used when evaluating conversion options and equipment requirements for the facility.

County	Corn Acres Harvested 1995 Crop Year Bushels	Collectible Stover 1993 Residue Tons	30% Acreage Participation @ 2.0 Tons/Acre	30% of Collectible Stover, Tons
York	242,000	249,000	145,200	104,700
Hamilton	250,400	305,000	150,240	91,500
Seward	125,100	86,000	75,060	25,800
Fillmore	180,800	186,000	108,480	55,800
Polk	150,800	137,000	90,480	41,100

Total Tons for Biomass Conversion	**569,460**	**to**	**318,900**

STOVER COLLECTION AND COSTS

Proprietary data[3] provided to High Plains Corporation indicates that this volume of stover can be harvested, baled, and transported to collection centers within 120 days of harvest at a delivered price of less than $35.00 per ton. Initial foray into this new feedstock at this volume will likely prove more costly until the collection centers and infrastructure are established.

DGS

The York facility uses approximately 13,800,000 bushels annually of grain to produce 36,000,000 gallons of anhydrous ethanol. The Distiller's Grains and Solubles (DGS) by-product will contain both insoluble portions of the spent grain combined with a portion of the soluble portions. The total plant output of soluble and insoluble solids (dry matter basis) is approximately 350 tons per day (124,250 annual tons). Testing analysis[5] indicates that 9% of this product is fermentable (enzyme soluble carbohydrate) and another 9% is fiber[6] that may be converted using cellulase technology. This equates to 63 tons per day of fermentable feedstock. Conversion of this 18% portion of the DGS to ethanol would also raise the protein level, which may add value to the remaining by-product. Conversely, addition of unconverted starches from the stover process along with the residual lignin and ash to the DDGS will significantly reduce the protein value.

CONVERSION – PLANT SIZE EVALUATION

Proponents[3] of various conversion technologies have professed to achieve up to 80% conversion of cellulose and hemi-cellulose to glucose, which equates to 135 gallons of ethanol per ton of biomass. Others have stated 75 gallons of ethanol per ton as a realistic goal. NREL has reported[7] that Corn Stover is 41% cellulose and 21% hemi-cellulose. If the conversion technology results in comparable corn/milo conversion, and the known corn/milo yield is 80 gallons of ethanol per dry ton of grain with 68% fermentable starches (2.6 gallons per bushel) then a ratio can be established to calculate theoretical stover yield. This relationship is shown in the following table.

For project evaluation, it is recommended that the conservative figure (or the average of the two assumptions) be used.

62 % "fermentables" in corn stover
68 % fermentables in corn/milo (starch, DMB)

80 gallons/ dry ton of corn/milo yield

64 gallon/ton assuming corn stover conversion is 80% of starch

$$\frac{62}{68} = \frac{X}{80}$$

$X = 73$ gallons/ton assuming conversion is equal

68 Gallons/ ton average of assumptions

Using this yield and the stover available from this research then 21,685,200 gallons can be produced from stover and 1,520,820 gallons from DDGS of anhydrous alcohol production.

References Cited

[1] *NEBRASKA AGRICULTURAL STATISTICS*, 1997 – 1998, Nebraska Dept. of Agriculture, Issued November 1998

[2] *Feasibility of Corn Residue Collection in Kearney, Nebraska Area*, Report of Findings for Western Regional Biomass Energy Program by University of Nebraska-Lincoln, Industrial Agricultural Products Center, September 1993.

[3] Summary notes of proprietary discussions with confidential business associate(s) by HIPC Plant Manager, D. Allison, 1998 - 1999.

[4] Report on Agricultural Residue Harvest and Collection, prepared for Western Regional Biomass Energy Program Western Area Power Administration by North Dakota State University, November 1994.

[5] Enzyme Development Corporation analysis report to Greg Heuer, HIPC Director of Plant Operations, October 19, 1998.

[6] Servi-Tech Laboratories Feed Analysis Report to HIPC, typical.

[7] NREL Memo, "Results of analytical analysis on fiber samples" to Danny Allison, HIPC from Kelly Ibsen, NREL, July 21 1998.

Appendix 2

MERRICK
Engineers & Architects

MERRICK & COMPANY
2450 S. Peoria Street
Aurora, CO 80014
303-751-0741
303-751-2581 fax

TRIP REPORT

DATE: **April 1 and 2, 1999**
PROJECT: **Building a Bridge to the Corn Ethanol Industry**
PROJ. NO.: **19013442**

LOCATION: **Iron Horse Custom Farming, Harlan, Iowa**
High Plains Corp. Ethanol Plant - York, Nebraska

ATTENDEES:		
	Danny Allison	**High Plains Corp.**
	Joe Casey	**High Plains Corp.**
	Dale Bender	**High Plains Corp.**
	Tom Schechinger	**Iron Horse Custom Farming, LLC**
	Dick Voiles	**Merrick & Company**

Visit to **Iron Horse Custom Farming in Harlan, Iowa**:

1. The corn stover harvest, last fall, was cancelled by Great Lakes Chemical at just under 50% completion. Great Lakes could not sell their products.
2. Because the stover demand has fallen from a forecast of 65,000 tons/year to about 30,000 tons/year, Iron Horse is selling some of their equipment. A high speed tractor in good conditions is valued at approximately $60,000 to $65,000..
3. Great Lakes produces furfural, furfural alcohol, and Furfafill (a by-product used as a glue extender in fiber board) at their Omaha plant.
4. Great Lakes burns about 50% of the Furfafill by-product for energy. For each 20 tons of stover a ton of ash is produced. This ash was originally sent to landfill but now most is applied to local fields.
5. Iron Horse was successful in changing Iowa law to allow custom hauling using the high speed tractors. These tractors have air ride, air brakes and other safety features. They are more stable and much easier to control than conventional tractors. These tractors are superior to trucks in collecting corn stover because they are better able to work in snowy, wet or heavily frosted fields. They are more economical than trucks within about 40 miles of the delivery point. The advantage for farm tractor/trailers averages $1.49/ton of stover within the 40 mile haul distance.
6. Many factors influence the collection of corn stover. Farms near river bottoms would like to remove essentially all of the stover. However, conventional methods allow a pick up of 60 to 70 % before the amount of dirt inadvertently picked up becomes excessive. Fields on hill sides generally yield less stover and leave much of it on the

field to prevent erosion. Approximately 40% of the stover must be collected to make the operation economically attractive.

7. Collected corn stover is put into bales by multiple, independent baling contractors. Although there are numerous baling contractors, experience has shown that only about 30% of these are reliable and have the skill to make good, dense bales that will transport economically and store well.
8. If bales are not dense the transportation costs become uneconomical. Large round bales should be about 1200 pounds dry weight. Skill in making the bales can vary this weight by as much as 600 pounds.
9. Large round bales wrapped in plastic netting for transportation and storage have advantages over twine wrapped bales. Bales held by either sisal or plastic twine do not store well and allow losses from the bale at highway speeds.
10. Setting up a collection program is time consuming. Farmers need to understand the benefits for their individual farms and be convinced to try stover collection. Each set back (such as cancelled harvest) undermines the trust that must be established. There are often several benefits for a farmer besides the actual price paid for the stover such as being able to get into the field earlier in the spring, saving on disking operations, offsetting some increase in fertilizer cost by savings in the soil nitrogen addition requirements.
11. Additional benefits will happen once the program is shown to be successful. For example, there are hybrids that produce the same corn yield but have more foliage – leading to more stover. These may become attractive to farmers who don't want them now.
12. To do a harvest effectively in the short time window available means that one must be over-equipped. Practical use of the equipment will require the harvesting of other materials not having the same schedule. This should be part of the overall plan. For example, switch grass could be harvested after the corn stover harvest is complete.
13. Farmers would be more comfortable if they had more than a single buyer for their product.

Visit to the Harlan terminal of Great Lakes Chemicals:

1. The terminal had approximately 40,000 bales stored on 8 to 10 acres surrounding a processing building. Of the 40,000 bales, 22,000 were from the most recent harvest. Bales are stored in rows, stacked three bales high. Dense bales, wrapped in plastic netting were storing well. Some of the bales were from the previous year's harvest (that is, they have been in storage since the fall of 1997). Low density bales and bales wrapped in twine were falling apart and could not be moved as a bale.
2. The processing center chops the raw stover and extrudes it into about 1-1/2" diameter by 4 to 6 inch long pellets or bricks. These are conveyed into large trucks for transport to the Great Lakes' Omaha plant. They have experimented with the extruder and found that they can vary the density of the pellets to meet plant requirements.

3. Examples of the several products which could be manufactured solely or partly from corn stover were available. Included were fiberboard, animal bedding, seeding mulch, furfural etc.

York Ethanol Plant:

1. Toured the plant with the potential addition of a corn stover/spent distillers grain (SDG) addition foremost in mind.
2. The beer column can handle nearly twice the current load thus potentially eliminating the need to duplicate for new throughput.
3. A single boiler can easily handle the average steam requirement. However both boilers are run continuously in a turned-down mode in case one should fail. If a new plant did not add a third boiler this standby or spare capability would be lost.
4. The air compressor may be adequate to handle a second plant.
5. Chilled water systems may be adequate for a second plant.
6. When able High Plains sells wet spent distillers grain cake to local feed lots thus saving the cost of drying. If SDG must be transported a significant distance, it is necessary to dry it.
7. Dry SDG can be loaded into rail cars using a horizontal auger that evenly loads the car. Trucks are loaded with a front loader.
8. A set of P&IDs, block flow diagram and descriptive information were given to Merrick for project use.
9. The high quality ethanol distillation section was shut down due to lack of product demand. This situation is not likely to continue.
10. There appears to be ample space for plant additions either as a separate plant or as an integrated plant. Feed stock storage must be separately evaluated.
11. High Plains has targeted the week of April 5, 1999 to supply a draft report to the project for their parts of the corn stover project. Some of the most important aspects are:
    - Assumed available corn stover is 30% of the produced corn stover in York County and the two adjacent counties. This is roughly equivalent to a 70 mile radius. It means that 400,000 to 500,000 tons per year of stover is available.
    - Placing a value on delivered stover is not easily done. One approach would be to back into the highest cost stover could be for the operation to be economically attractive.
    - Based on 77 gallons of ethanol production from each ton of corn stover, the plant capacity will be roughly 36 million gallons per year. Published ethanol yields from corn stover vary from 75 to 135 gallons/ton. The value of 77 was selected to match an NREL paper that equated corn stover yield to 62% of corn grain yield.
12. NREL (Kelly Ibsen) has a consistent set of utility prices for the York plant, which she is using in developing an ASPEN Plus™ model. These utility prices should be used for this project.
13. York recently added a RO unit on boiler feed water, in which, will reduce the cost for this commodity. RO is due to high silica in the feed water.

14. Plant raw water is from three wells located on-site.
15. SDG is produced at the rate of 300 tons/day.
16. Some important questions which we must address during the course of this project are:
    - SDG is sold for $100 per dry ton as animal feed. Is this not too high a value for ethanol feed?
    - If SDG is fed to the ethanol plant presumably the volume of solids would be reduced as cellulase breaks down much of the fiber. However, there may be no effect on the proteins which are the basis of the live stock feed price. It may be that the value per ton as animal feed will increase if SDG is processed without stover?
    - There is a belief that the corn plant and the stover plant cannot merge until after distillation. Is there a basis for this?
    - The 300 tons per day of SDG yields 2 million gallons of ethanol per year. Does this small yield justify the cost of investigation in this study?
    - An alternative to increasing the overall ethanol production at York is to blend stover into the existing plant feedstock by backing out corn grain and observing the economic effects.

MERRICK
Engineers & Architects

MERRICK & COMPANY
2450 S. Peoria Street
Aurora, CO 80014
303-751-0741
303-751-2581 fax

TRIP REPORT

DATE: November 3, 1999
PROJECT: Building a Bridge to the Corn Ethanol Industry
PROJ. NO.: 19013442

LOCATION: High Plains Corp. Ethanol Plant - York, Nebraska

ATTENDEES:

Brian Pasbrig	High Plains Corp.
James Atmore	High Plains Corp.
Dale Bender	High Plains Corp.
Dick Voiles	Merrick & Company

On November 3rd, 1999 I traveled to York, Nebraska to visit the High Plains grain to ethanol production facility. The purpose of this visit was to discuss the potential placement of equipment in a new corn stover facility that would be built and operated at the same location.

The following is a compilation of notes taken during the visit.

Met Dale Bender (operations manager). Mr. Bender set up a meeting with Brian Pasbrig and James Atmore to discuss the various questions with me.

I expalined that my initial layout located the new facilities North of the administration offices in the cropland owned by High Plains.

- The bale receiving area (500 ft. x 500 ft.) would be located adjacent to the N/S road to the east. – The bale receiving area should have a separate access entrance with separate weigh in/out scales due to the current truck traffic entering the plant. Discussed having a separate access road from highway 34 for the bale receiving area and believe that this is possible, however the county would be less likely to approve an exit from highway 34 due to the number of trucks anticipated.

- The stover feedstock storage area was discussed. –The loader for this area should be included in the capital cost estimate as sharing a loader with the existing facility would be impractical due to the usage.

- Discussed the hydrolysis/fermentation building location and layout. – Location N. of the current fermentation building looks good. The building layout should be mirror image to the existing building with respect to tanks. Areas should be designated for control room, QC Lab, operator lab, and offices. Integration with the existing DCS system will need to be incorporated into the project, and possibly a central control room for both plants will need to be installed. The existing ammonia tank can be shared. The sulfuric acid tank should be added for a new facility. These tanks are presently loaded by truck.. The loading facilities can be used and transferred to the new facilities. The fermentor seed tanks should be located near the fermentors. The celulase enzyme production systems should be located in a separate building to the north.

- The material handling systems were discussed along with a new rail spur for lignin loadout and lime handling.

  - The current DDG rail spur (running N/S) might be extended north to allow use for lignin loadout, however the amount of rail traffic anticipated and rail car staging would likely interfere with the current truck traffic for grain unloading. This option could be studied further but at present does not appear to be feasable. A new rail spur to the ease of the DDG Loadout may be more practical.

  - Locating the evaporator and centrifuge area near the existing E/W rail spurs and pumping the slurry across the existing facility was also discussed. The lignin handling area could then be located east of the existing DDG facility and could use the DDG loadout spur (or supplement the spur) with minimum impact on the existing truck traffic.

  - The existing centrifuge building has spare locations for additional centrifuges. Locating the lignin centrifuges in this building would save significant capital costs due to the building costs being eliminated.

  - The lignin area should have a surge pit for conveyor upsets.

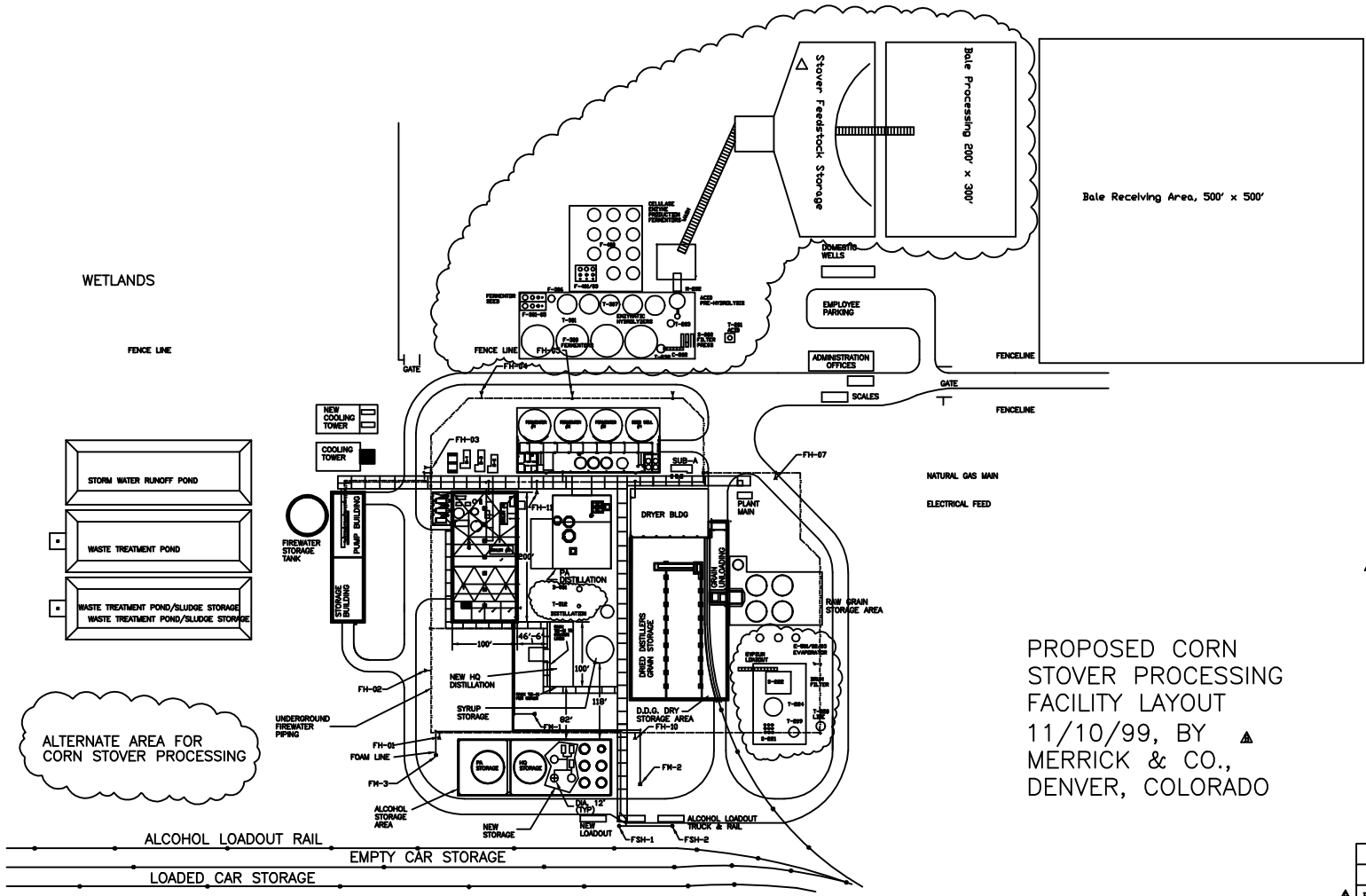
- The existing distillation area and mol sieve could be expanded to allow processing of the new stream. In particular if a preliminary separation was made (to say 160 proof) then the existing facility could probably handle the final refining. The movement of slurry across the plant becomes more attractive if the existing distillation facilities can be expanded to handle the extra capacity.

- The gypsum and lime handling would then be located near the lignin loadout area.

- Plant walkdown also revealed an area used for equipment laydown that could be used. An alternate layout will be produced that shows the new facility in the SW corner of the plane with access from the west (road one mile west). This option would allow minimal impact to the existing operation.

- The existing electrical capacity of the plant was discussed with Mike Kriewald. The line capacity to the substation should be adequate for the new facility, however a new 34.5 KV to 480 V transformer would be required for the new plant.

Appendix 3



PROPOSED CORN STOVER PROCESSING FACILITY LAYOUT
11/10/99, BY ⚠ MERRICK & CO., DENVER, COLORADO

REV	DESCRIPTION	DATE	BY
B	PER PLANT LAYOUT	10/25/96	KLK
A	GENERAL REVISION	10/24/96	KLK

FAGEN ENGINEERING LLC
Civil - Structural
Mechanical - Electrical
Engineers
(320) 564-4573
501 W. Hwy. 212, P.O. Box 159
Granite Falls, MN. 56241

JOB: HIGH PLAINS CORP YORK, NE

LOCATION: YORK, NE	DRAWN BY: D.C.	CHECKED BY: D.H.
ENGINEER: FAGEN ENGINEERING, LLC	SCALE: 1" = 50'	DATE: 9/5/96
CONTRACTOR:	JOB NUMBER	SHEET NUMBER
DESCRIPTION: SITE PLAN	EG1013	21-01

Cellulase Enzyme Dosage Study
Jim Linden
28. July 1999

I have reviewed literature published during the past ten years that describes the effects of cellulase enzyme dosage on extend and time dependence of hydrolysis of pretreated lignocellulose. The data has been collected with the purpose providing a recommendation regarding over-capacity of enzyme production for the Separate Hydrolysis and Fermentation (SHF) process under consideration. Ten relevant papers were found; the important facts from each will be reviewed in order of chronological appearance.

Comparisons of enzyme dosage and *Trichoderma* enzyme manufacturer with the hydrolysis of pretreated aspen wood was presented by Schwald et al. in 2 to 60 L reaction vessels (1). Over 85% of the cellulose could be hydrolyzed to glucose in 96 hours when an 8% substrate concentration was used with 9 FPU/g substrate. The same average conversion appeared to be complete in 48 hours when 17 FPU/g substrate was used. A visual estimation can be made from the attached figure (schwfig1).

Two related papers by Spindler, Wyman and Grohmann from NREL appeared in 1990 that described Simultaneous Saccharification and Fermentation (SSF) of dilute sulfuric acid pretreated herbaceous crops, which included corn stover (2, 3). Little difference was found in final yield between the low and high cellulase enzyme loadings. In all cases, SSFs showed faster and higher conversion than SHFs for the same enzyme loadings. For instance, comparison of 13 and 26 IU/g cellulose loadings with beta-glucosidase supplementation, corn stover SSF theoretical yields after seven days were 86 and 92 percent, respectively. Table 1 from reference 2 is duplicated as an attachment (spintab1).

A 1994 paper by Penner and Liaw provided some kinetic modeling for the *Trichoderma* cellulase system (4). Under conditions of substrate inhibition using high ratios of substrate to enzyme, the relative enzyme hydrolysis rate varied only 30 micromol/h over the range from 10 to 100 FPU / g microcrystalline cellulose substrate.

A paper in 1996 contained exactly the kind of information desired (5). The effect of enzyme loading on ethanol production in batch SSF of pretreated sugar cane bagasse using 7, 15 and 30 FPU / g cellulose was given in Figure 2, which is attached (lynnfig2). Ethanol production plateaus after 50 hours using 30 FPU / g. Treatment with 15 FPU / g had produced approximately 80% that of former case in 50 hours and 100% that of the former case in 300 hours. These data indicated an advantage of using the greater loading in SSF. Presumably similar results would be obtained in SHF. However, when examining the conversion based on cellulose concentration, the decline in final substrate utilization with declining enzyme loading was small. The effect was thought possibly to be pretreatment dependent, rather than a substrate-

specific effect that might result from reduced inactivation of enzyme owing to the low lignin content of the pretreated material.

An alkaline pretreatment of corn stover was studied in a 1998 paper by Belkacemi et al. (6). Saccharification of the pretreated material was followed by fermentation, hence SHF. Indeed 55-70% of the cellulose was hydrolyzed after 48 hours, and the extent of hydrolysis was dependent not only on cellulase units, but also more dramatically on the amount of beta-glucosidase added to the system. This finding supports data of Spindler et al. (2, 3) that is presented above. Increasing the solids loading to 10% (w/v) during hydrolysis from 5% almost reduced the saccharification by half.

Baker et al. from NREL continued studies on enzyme mixtures using purified enzymes in a 1998 paper (7). Results revealed that at least one synthetic mixture utilizing enzymes from three different organisms delivers performance competitive with that of a "native" *T. reesei* system.

In conclusion, increasing the enzyme dosage by a factor of two appears to reduce the time to similar extent of conversion by from 10% (2) to50% (1) to 75% (5). The range encompasses different substrates and different enzyme systems. Certainly, using an enzyme system with sufficient beta-glucosidase reduces the advantage. Also, using easily convertable substrates, such as corn stover, reduces the advantage. Knowing that the cost of enzyme production contributes very significantly to the product value, I would find it prudent to use 15 FPU/g cellulose for SHF, especially since the enzyme produced on pretreated corn stover should have superior characteristics for hydrolysis of the same substrate (8).

Bibliography

1. Schwald, W. et al. 1989. Assessment of Pretreatment Conditions to Obtain Fast Complete Hydrolysis on High Substrate Concentrations. Appl. Biochem. Biotechnol. 20/21:29-44.

2. Spindler, D. et al. 1990. Ethanol Production by Simultaneous Saccharification and Fermentation (SSF) of Pretreated Corn Cobs and Corn Stover. Proceedings of Corn Utilization Conference III, St. Louis, MO, June 19-21.

3. Spindler, D. et al. 1990. Evaluation of Pretreated Herbaceous Crops for the Simultaneous Saccharification and Fermentation Process. Appl. Biochem. Biotechnol. 24/25:275-286.

4. Penner, M.H. and Liaw, E.-T. 1994. Kinetic Consequences of High ratios of Substrate to Enzyme Saccharification Systems based on *Trichoderma* Cellulase. In Enzymatic Conversion of Biomass for Fuels Production, (M.E. Himmel, J.O. Baker and R.P. Overend, eds). ACS Symposium Series 566, American Chemical Society, Washington D.C., pp. 363-371.

5. Van Walsum, G.P. et al. 1996. Conversion of Lignocellulosics Pretreated with Liquid Hot Water to Ethanol. Appl. Biochem. Biotechnol. 57/58:157-170.

6. Belkacemi, K. et al. 1998. Ethanol Production from AFEX-Treated Forages and Agricultural Residues. Appl. Biochem. Biotechnol. 70/72:441-462.

7. Baker, J.O. et al. 1998. Hydrolysis of Cellulose Using Ternary Mixtures of Purified Cellulases. Appl. Biochem. Biotechnol. 70/72:395-403.

8. Philippidis, G.F. 1994. Cellulase Production Technology: Evaluation of Current Status. In Enzymatic Conversion of Biomass for Fuels Production, (M.E. Himmel, J.O. Baker and R.P. Overend, eds). ACS Symposium Series 566, American Chemical Society, Washington D.C., pp. 188-217.

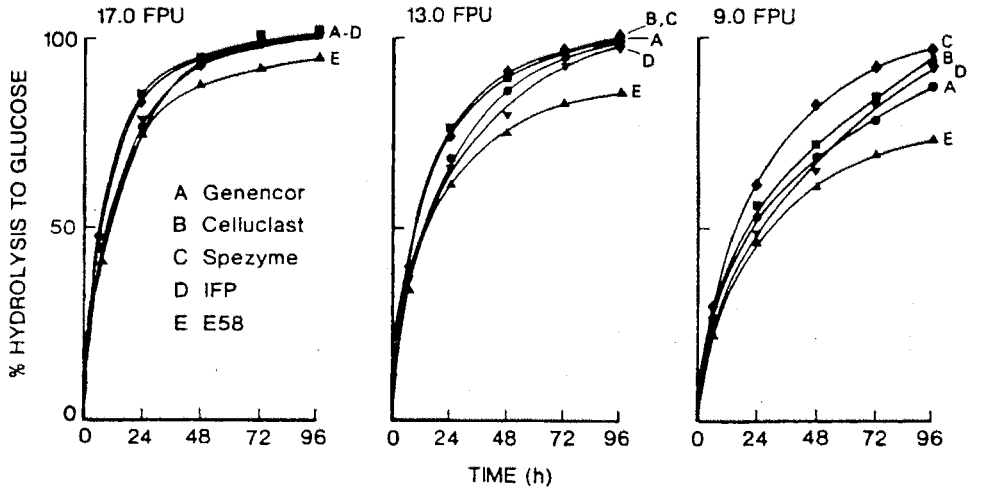


Fig. 1. Effect of enzyme concentration (FPU/g substrate) on enzymatic hydrolysis of pretreated aspen wood using various enzyme preparations supplemented with β-glucosidase (Novozym) to a constant level of cellobiase activity.

Tab. 1. SSF - Final (7 day) percent theoretical yields for *S. cerevisiae* and mixed culture at selected cellulase enzyme loadings with and without β-glucosidase supplementation on dilute acid pretreated corn residue crops at 37°C.

	S. cerevisiae							
IU β-glucosidase: IU Cellulose	0:1				8:1			
IU Cellulase/g Cellulose	7	13	19	26	7	13	19	26
Corn Cob	58	63	80	87	87	91	94	94
Corn Stover	54	59	77	84	82	86	90	92
	*Mixed Culture							
Corn Cob	76	85	89	92	92	93	96	96
Corn Stover	75	84	87	89	86	89	92	92

SAC - Final (7 day) saccharification yields for acid pretreated corn cob and stover at selected cellulase enzyme loadings with and without β-glucosidase supplementation at 45°C.**

IU Cellulase/gm Cellulose	7	13	19	26	7	13	19	26
Corn Cob	55	64	78	86	69	83	90	90
Corn Stover	48	64	77	84	64	80	86	89

* Mixed culture: *Saccharomyces cerevisiae* and *Brettanomyces clausenii.*
**Saccharifications are expressed in percent of theoretical conversion.

Appendix 4

Water Balance

PFD-P101-A201

	STREAM	kg/hr	total
IN	101	34,477	
	211	23,080	
	215	7,622	
	216	18,191	
			83,369
OUT	220	62,902	
	520	19,472	
			82,375
Total for PFD			994

PFD-P101-A202

	STREAM	kg/hr	total
IN	220	62,902	
	219	61,082	
	243	18,005	
	245	13,821	
	230	92,637	
			248,447
OUT	247	28,353	
	246	91,676	
	303	12,194	
	403	242	
	410	4,597	
	302	111,360	
			248,423
Total for PFD			25

PFD-P101-A203

	STREAM	kg/hr	total
IN	246	91,676	
			91,676
OUT	230	92,637	
	229	207	
			92,844
Total for PFD			(1,167)

PFD-P101-A301

	STREAM	kg/hr	total
IN	303	12,194	
	421	1,623	
			13,817
OUT	304c	8	
	304	13,781	
			13,789
Total for PFD			28

PFD-P101-A302

	STREAM	kg/hr	total
IN	304	13,781	
	302	121,909	
	551	6,640	
			142,329
OUT	308	141	
	502	139,868	
			140,009
Total for PFD			2,320

PFD-P101-A307

	STREAM	kg/hr	total
IN	302A	111,360	
	307A	10,149	
	422	10,548	
			132,057
OUT	302B	121,909	
	307B	10,149	
			132,057
Total for PFD			-

PFD-P101-A401

	STREAM	kg/hr	total
IN	403	242	
	430	783	
			1,025
OUT	433	866	
	435	182	
			1,048
Total for PFD			(23)

PFD-P101-A402

	STREAM	kg/hr	total
IN	410	4,597	
	433	866	
	411	7,777	
			13,240
OUT	419	1,537	
	421	1,623	
	422	10,548	
			13,709
Total for PFD			(469)

PFD-P101-A501

	STREAM	kg/hr	total
IN	501	139,868	
			139,868
OUT	508	11	
	510	13,909	
	518A	125,948	
			139,868
Total for PFD			-

PFD-P101-A502

	STREAM	kg/hr	total
IN	304c	8	
	308	141	
	508	11	
	524	6,564	
	510	13,909	
	521	879	
			21,512
OUT	550	83	
	551	6,640	
	516	13,919	
	511	924	
			21,565
Total for PFD			(53)

PFD-P101-A503

	STREAM	kg/hr	total
IN	511	924	
			924
OUT	521	879	
	515	45	
			924
Total for PFD			-

PFD-P101-A504

	STREAM	kg/hr	total
IN	518A	125,948	
	610	59,091	
			185,039
OUT	211	22,816	
	243	17,623	
	245	13,664	
	535	10,342	
	531	17,879	
	525	103,980	
			186,303
Total for PFD			(1,264)

PFD-P101-A601

	STREAM	kg/hr	total
IN	604	36,924	
	516	13,919	
	525	103,980	
	531	17,879	
			172,702
OUT	219	61,082	
	411	7,777	
	430	783	
	610	59,091	
	601B	43,969	
			172,702
Total for PFD			-

PFD-P101-A602

	STREAM	kg/hr	total
IN	520	19,472	
	535	10,342	
	494	6,842	
	821	2,699	
	247	28,353	
			67,708
OUT	624	67,708	
			67,708
Total for PFD			-

PFD-P101-A801

	STREAM	kg/hr	total
IN	813	80,536	
			80,536
OUT	815A	12,060	
	215	7,622	
	594	25,190	
	592	3,230	
	237	1,167	
	596	229	
	216	18,191	
	307	10,149	
	821	2,699	
			80,536
Total for PFD			0

PFD-P101-A802

	STREAM	kg/hr	total
IN	815A	12,060	
	811	29,678	
	593	3,230	
	595	25,190	
	307	10,149	
	597	229	
	821	2,699	
			83,235
OUT	813	80,536	
	821	2,699	
			83,235
Total for PFD			-

PFD-P101-A901

	STREAM	kg/hr	total
IN	941	75,268	
	945	5,553,810	
	950	2,276,429	
			7,905,507
OUT	949	64,004	
	940	5,553,810	
	942	4,422	
	944	6,842	
	951	2,276,429	
			7,905,506
Total for PFD			0

PFD-P101-A902

	STREAM	kg/hr	total
IN	904	79,972	
	624	67,708	
			147,680
OUT	524	6,786	
	811	29,678	
	604	36,924	
	906	28	
	941	75,268	
			148,685
Total for PFD			(1,005)

	IN	OUT
Process Totals	9,530,671	9,531,285
NET	(614)	
	-0.01% of in	

Facility Summary
stream numbers

IN		OUT	
114,449	101	435	114,449
	904	419	balance
		550	0
		620	
		949	
		942	
		229	
		601B	
		515	

Appendix 5

quip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Install Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description	3442 WORK		NREL 900TPD
01	1	0	Bale conveyor	AREA0100	154	170	1.11	$15,000	1999	$15,000	0.6	$15,927	1.5	$24,551	$ 15,927	wire mesh conveyor 60" wide 20' long	WC101	11.93	
02	1	0	Radial Stacker Conveyor	AREA0100	154	170	1.11	$159,830	1999	$159,830	0.6	$169,708	1.5	$261,604	$ 169,708	16 degree, 36" x 200' radial stacker, 750 ton/hr, 75 HP	WC102	44.74	
03	1	0	Breaker Infeed Belt	AREA0100	154	170	1.11	$49,500	1999	$49,500	0.6	$52,559	1.5	$81,020	$ 52,559	84" x 35' rubber belt cleated infeed conveyor, 10 HP, TEFC drive motor with guard	WC103	5.97	
04	1	0	1st Shredder Conveyor	AREA0100	154	170	1.11	$25,650	1999	$25,650	0.6	$27,235	1.5	$41,983	$ 27,235	60" wide x 25' long, 10 HP, TEFC drive with guard	WC104	5.97	
05	1	0	1st Infeed Belt	AREA0100	154	170	1.11	$38,500	1999	$38,500	0.6	$40,879	1.5	$63,015	$ 40,879	60" wide x 30' long, 10 HP, TEFC drive with guard	WC105	11.93	
06	1	0	2nd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.5	$48,285	$ 31,323	48" wide x 20' long, 7.5 HP, TEFC drive with guard	WC106	4.47	
07	1	0	2nd Infeed Belt	AREA0100	154	170	1.11	$27,500	1999	$27,500	0.6	$29,200	1.5	$45,011	$ 29,200	48" wide x 30' long, 5 HP, TEFC drive with guard	WC107	2.98	
08	1	0	3rd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.5	$48,285	$ 31,323	48" wide x 20' long, 10 HP, TEFC drive with guard	WC108	5.97	
09	1	0	Feed Screw Conveyor	AREA0100	225,140	562,850	2.50	$31,700	1997	$31,700	0.6	$54,932	1.5	$86,351	$ 56,018	14" dia. 250' long	WC109	53.75	
01	2	0	Truck Scale	AREA0100	96	72	0.75	$10,000	1999	$20,000	0.6	$16,829	1.5	$25,244	$ 16,829	96 deliveries /scale/12hr			
02	1	0	Receiving Pad	AREA0100	250,000	250,000	1.00	$2,083,500	1999	$2,083,500	0.6	$2,083,500	1.0	$2,083,500	$ 2,083,500	250,000 ft2 concrete pad, 9" thick with drainage			
03	6	1	Front End Loader	AREA0100	159,948	159,948	1.00	$156,000	1998	$1,092,000	0.6	$1,092,000	1.2	$ 1,326,016	$ 1,105,013	run on gasoline			
04	3	0	Bale Breaker	AREA0100	154	170	1.11	$250,000	1999	$750,000	0.6	$796,352	1.2	$955,622	$ 796,352	30 HP each	WM104	53.69	
05	1	0	Primary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.2	$135,444	$ 112,870	250 HP, 1200 rpm, hammermill	WM105	149.14	
06	1	0	Secondary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.5	$169,304	$ 112,870	250 HP, 1200 rpm, hammermill	WM106	149.14	
07	1	0	Shred Bunker	AREA0100	600,000	600,000	1.00	$700,000	1999	$700,000	0.6	$700,000	1.0	$700,000	$ 700,000	200x100x30ft bunker with three walls, 3 days shred storage			
08	1	0	Storm Runoff Pond	AREA0100	1,747,767	1,747,767	1.00	$51,198	1998	$51,198	0.6	$51,198	1.0	$51,198	$ 51,808	200 x 150 x 8 ft, 240,000ft3			295.80
0										weighted averages:	0.60		1.13					499.68	295.80
										Subtotal	$5,315,978	$5,418,705		$6,146,434	$5,433,414				
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.3	$3,181,636	($2,964,798)	is installed cost savings			
												Cost Base Year =	1999						
01	1	0	In-line Sulfuric Acid Mixer	STRM0214	55,308	23,725	0.43	$1,900	1997	$1,900	0.48	$1,266	1.2	$1,585	$1,291	Static Mixer, 110 gpm total flow			
02	1	0	In-line NH3 Mixer	STRM0244	53,630	18,317	0.34	$1,500	1997	$1,500	0.48	$896	1.2	$1,122	$913	Static Mixer, 82 gpm total flow			
09	1	0	Overliming Tank Agitator	STRM0228	167,050	102,608	0.61	$19,800	1997	$19,800	0.51	$15,442	1.2	$19,345	$15,748	Top Mounted, 1800 rpm, 15 hp	WT209	8.39	11.11
24	1	0	Reacidification Tank Agitator	STRM0239	167,280	102,752	0.61	$65,200	1997	$65,200	0.51	$50,851	1.2	$63,702	$51,857	Top-Mounted, 1800 rpm, 54 hp	WT224	25.17	44.49
32	1	0	Reslurrying Tank Agitator	STRM0250	358,810	167,795	0.47	$36,000	1997	$36,000	0.51	$24,432	1.2	$30,606	$24,915	Top-Mounted, 1800 rpm, 25 hp	WT232	13.98	11.99
35	1	0	In-line Acidification Mixer	STRM0236	164,570	101,104	0.61	$2,600	1997	$2,600	0.48	$2,058	1.2	$2,578	$2,099	Static-Mixer, 440 gpm total flow			
01	1	0	Hydrolyzate Screw Conveyor	STRM0220	225,140	101,493	0.45	$59,400	1997	$59,400	0.78	$31,908	1.5	$50,158	$32,539	18" dia. 33' long, 3420 cfh max flow, 23 hp	WC201	13.72	13.83
02	1	0	Wash Solids Screw Conveyor	STRM0225	196,720	165,453	0.84	$23,700	1997	$23,700	1	$19,933	1.5	$31,334	$20,327	18" dia, 16' long, 3420 cfh max flow	WC202	16.70	16.42
25	1	0	Lime Solids Feeder					$3,900	1997	$3,900	1	$3,900	1.5	$6,131	$3,977	6" dia., 63 cfh, 3150 lb/hr max flow	WC225	0.15	0.12
00	1	0	Hydrolyzate Cooler	AREA0200	1,988	895	0.45	$45,000	1997	$45,000	0.51	$29,947	2.2	$66,543	$30,539	Fixed Tube Sheet, 900 sf, 20' dia. X 20' long			
01	1	1	Beer Column Feed Economizer	AREA0201	5,641	5,641	1.00	$139,350	1999	$278,700	0.68	$278,700	2.2	$607,278	$278,700	TEMA type AES shell and tube 5641 sf, 42" dia x 20' long			
02	1	0	Prehydrolysis Reactor	STRM0217	270,034	121,514	0.45	$12,461,841	1998	$12,461,841	0.78	$6,684,746	1.5	$10,146,612	$6,764,408	Vertical Screw, 10 min residence time	WM105	353.16	353.16
01	1	1	Sulfuric Acid Pump	STRM0710	1,647	414	0.25	$4,800	1997	$9,600	0.79	$3,228	2.8	$9,190	$3,291	2 gpm, 245 ft head	WP201	0.40	0.27
09	1	1	Overlimed Hydrolyzate Pump	STRM0228	167,050	102,608	0.61	$10,700	1997	$21,400	0.79	$14,561	2.8	$41,458	$14,849	448 gpm, 150 ft head	WP209	18.01	24.63
22	1	1	Filtered Hydrolyzate Pump	STRM0230	162,090	101,614	0.63	$10,800	1997	$21,600	0.79	$14,936	2.8	$42,526	$15,231	448 gpm, 150 ft head	WP222	17.83	24.52
23	1	0	Lime Unloading Blower	STRM0227	547	337	0.62	$47,600	1998	$47,600	0.5	$37,340	1.4	$52,898	$37,785	3341 cfm, 6 psi, 10,024 lb/hr	WP223	4.10	4.10
24	1	1	Hydrolysis Feed Pump	STRM0250	160,000	167,795	1.05	$64,934	1999	$129,868	0.6	$133,628	1.2	$160,354	$133,628	740 gpm, 240 ft head	WP224	119.31	27.70
25	1	1	ISEP Elution Pump	STRM0243	52,731	18,005	0.34	$7,900	1997	$15,800	0.79	$8,761	2.8	$19,249	$8,894	104 gpm, 150 ft head	WP225	3.52	3.55
26	1	1	ISEP Reload Pump	STRM0246	164,080	100,802	0.61	$8,700	1997	$17,400	0.79	$11,841	2.8	$33,714	$12,075	445 gpm, 150 ft head	WP226	17.92	12.04
27	1	1	ISEP Hydrolyzate Feed Pump	STRM0221	160,290	98,157	0.61	$10,700	1997	$21,400	0.79	$14,526	2.8	$41,359	$14,814	432 gpm, 150 ft head	WP227	16.81	24.12
39	1	1	Reacidified Liquor Pump	STRM0239	167,280	102,752	0.61	$10,800	1997	$21,600	0.79	$14,698	2.8	$41,847	$14,988	450 gpm, 100 ft head	WP239	12.09	16.47
02	3	0	Pre-IX Belt Filter Press	SOLD0220	57,000	57,000	1.00	$200,000	1998	$600,000	0.39	$600,000	1.4	$850,010	$607,150	Use 3 units for 45% of the flow as recommended by the vendor	WS202	19.69	19.19
21	1	0	ISEP	STRM0240	210,005	98,157	0.47	$2,058,000	1997	$2,058,000	0.33	$1,601,194	1.2	$1,959,422	$1,632,851	10 chambers (39" dia. X 84" high), 4" dia. Valve - Weak Base Resin	WS221	2.98	2.24
22	1	0	Hydroclone & Rotary Drum Filter	STRM0229	5,195	1,137	0.22	$165,000	1998	$165,000	0.39	$91,224	1.4	$129,235	$92,311	Hydrocyclone and Vacuum Filter for 453 gpm	WS222	11.93	11.60
27	1	0	LimeDust Vent Baghouse	STRM0227	548	337	0.61	$32,200	1997	$32,200	1	$19,778	1.5	$30,254	$20,169	3750 cfm, 625 sf, 6 cfm/sf			
01	1	0	Sulfuric Acid Storage	STRM0710	1,647	860	0.52	$5,760	1998	$5,760	0.71	$3,633	1.7	$6,283	$3,751	2000 gal., 24 hr. residence time, 90% wv, 5.5ft diam. X 11ft			
03	1	0	Blowdown Tank	STRM0217	270,300	121,514	0.45	$64,100	1997	$64,100	0.93	$30,475	1.7	$52,061	$31,078	7000 gal., 11' dia x 30' high, 10 min. res. time, 75% wv, 15 psig			
09	1	0	Overliming Tank	STRM0228	167,050	102,608	0.61	$71,000	1997	$71,000	0.71	$50,232	1.8	$90,186	$51,225	29850 gal., 16' dia. X 32' high, 1 hr. res. time, 90% wv, 15 psig			
20	1	0	Lime Storage Bin	STRM0227	548	548	1.00	$69,200	1997	$69,200	0.46	$69,200	1.8	$124,243	$70,568	4455 cf, 14' dia x 25' high, 1.5x rail car vol., atmospheric, 15 day storage max			
24	1	0	Reacidification Tank	STRM0239	102,752	102,752	1.00	$111,889	1999	$111,889	0.51	$111,889	1.8	$196,992	$111,889	120,000 gal., 28' dia x 28' high, 4 hr. res. time, 90% wv, atmospheric			
12	1	0	Slurrying Tank	STRM0250	358,810	167,795	0.47	$44,800	1997	$44,800	0.71	$26,117	1.8	$46,890	$26,633	11300 gal., 13' dia. X 25' high, 15 min. res. time, 90% wv			
									1999						$0				
0										weighted averages:	0.70		1.48					676.27	621.55
										Subtotal	$16,527,758	$9,999,337		$14,955,166	$10,128,493				
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.5	$15,025,380	$70,213	is installed cost savings			

quip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Install Factor	Installed Cost	Scaled UnInstalled Cost in 1999$	Description	3442 WORK		NREL 900TPD
00	8	0	Fermentor Agitators	GALLONS	962,651	750,000	0.78	$19,676	1996	$157,408	0.51	$138,592	1.2	$175,799	$143,110	Side Mounted, 2 per vessel, 60 hp each, 0.15 hp/1000 gal	WT300	261.34	354.50
01	1	0	Seed Hold Tank Agitator	STRM0304	41,777	17,529	0.42	$12,551	1996	$12,551	0.51	$8,060	1.2	$10,223	$8,322	Top Mounted, 1800 rpm, 10 hp, 0.1 hp/1000 gal	WT301	5.59	9.44
04	2	0	4th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$11,700	1997	$23,400	0.51	$15,026	1.2	$18,824	$15,323	Top Mounted, 1800 rpm, 3 hp, 0.3 hp/1000 gal	WT304	3.36	4.72
05	2	0	5th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$10,340	1996	$20,680	0.51	$13,280	1.2	$16,845	$13,713	Top Mounted, 1800 rpm, 9 hp, 0.1 hp/1000 gal	WT305	10.07	15.73
06	1	0	Beer Well Agitator	STRM0502	381,700	173,737	0.46	$10,100	1997	$10,100	0.51	$6,761	1.2	$8,469	$6,894	Top Mounted, 1800 rpm, 2 hp, 0.3 hp/1000 gal	WT306	1.12	1.21
00	4	0	Fermentors	GALLONS	750,000	750,000	1.00	$326,203	1999	$1,304,812	0.71	$1,304,812	1.8	$2,297,260	$1,304,812	750,000 gal. each, 2 day residence total, 90% wv, API, atmospheric, 50' ϕ x 51'			
01	2	0	1st Fermentation Seed Fermentor	None			0.45	$14,700	1997	$29,400	0.93	$13,991	2.8	$39,948	$14,267	9 gal, jacketed, agitated, 1' dia., 1.5' high, 15 psig			
02	2	0	2nd Fermentation Seed Fermentor	None			0.45	$32,600	1997	$65,200	0.93	$31,027	2.8	$88,592	$31,640	90 gal., jacketed, agitated, 2' 3" dia., 3' high, 2.5 psig			
03	2	0	3rd Fermentation Seed Fermentor	None			0.45	$81,100	1997	$162,200	0.93	$77,186	2.8	$220,394	$78,712	900 gal., jacketed, agitated, 5' dia, 6.5' high, 2.5 psig			
04	2	0	4th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$39,500	1997	$79,000	0.93	$35,225	1.7	$60,174	$35,921	9000 gal., 9' dia x 19' high, atmospheric			
05	2	0	5th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$147,245	1998	$294,490	0.51	$189,107	1.8	$336,910	$191,360	90000 gal., API, atmospheric 25'ϕ x 25'			
00	4	1	Fermentation Cooler	QHX300EA	67,820	25,053	0.37	$4,000	1997	$20,000	0.78	$9,198	2.2	$20,438	$9,380	4 exchangers at 221 sf, U=300 BTU/hr sf F LMTD = 22.9°F plate and frame			
01	1	0	Fermentation Seed Hydrolyzate Cooler	AREA0301	773	318	0.41	$15,539	1998	$15,539	0.78	$7,778	2.2	$17,151	$7,871	348 sf, 300 BTU/hr sf F			
02	1	0	Fermentation Pre-Cooler	AREA0302	3,765	828	0.22	$25,409	1998	$25,409	0.78	$7,797	2.2	$17,193	$7,890	828 sf total, plate and frame			
04	1	0	4TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$3,300	1997	$3,300	0.83	$1,580	1.2	$1,934	$1,611	12 sf, 1" sch 40 pipe, 105 BTU/hr sf F			
05	1	0	5TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$18,800	1997	$18,800	0.98	$7,881	1.2	$9,644	$8,037	138 sf, 2" sch 40 pipe, 92 BTU/hr sf F			
00	4	1	Fermentation Recirc./Transfer Pump	QHX300EA	67,737	55,505	0.82	$8,000	1997	$40,000	0.79	$34,177	2.8	$97,307	$34,852	844 gpm @ 150 ft sized based on heating rate	WP300	104.49	277.00
01	1	1	Fermentation Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$22,194	1998	$44,388	0.7	$24,168	1.4	$34,238	$24,456	280 gpm @ 150 ft head	WP301	5.95	6.92
02	2	0	Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$54,088	1998	$108,176	0.7	$58,898	1.4	$83,440	$59,600	504 gpm total, 252 gpm each, 100 ft head	WP302	7.14	6.92
06	1	1	Beer Transfer Pump	STRM0502	381,701	173,737	0.46	$17,300	1997	$34,600	0.79	$18,579	2.8	$52,899	$18,947	790 gpm each, 171 ft head	WP306	34.47	45.74
01	1	0	Fermentation Seed Hold Tank	STRM0304	41,777	17,529	0.42	$161,593	1998	$161,593	0.51	$103,767	1.8	$184,870	$105,003	105000 gal., API atmospheric			
06	1	0	Beer Well	STRM0502	129,000	183,467	1.42	$111,889	1999	$111,889	0.51	$133,906	1.8	$235,756	$133,906	192,518 gal., 32' dia x 32' high, 4 hr. res. time, 95% wv, atmospheric			
										weighted averages:	0.68		1.79				373.53	722.18
00									Subtotal	$2,742,935		$2,240,795		$4,028,307	→ $2,255,629				
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)					1.3	$8,218,509	→ $4,190,202	is installed cost savings			
07	8	0	Enzymatic Hydrolysis Tank Agitators	STRM0302B	157,136	157,136	1.00	$19,676	1996	$157,408	0.51	$157,408	1.2	$199,666	$162,539	two side mounted 75 hp agitators / tank, 0.4hp/1000 gal.	WT307	251.67	
07	12	0	Enzymatic Hydrolysis Tank Heater	STRM0302B	157,136	157,136	1.00	$15,000	1999	$180,000	0.78	$180,000	2.2	$392,214	$180,000	65 ft2 double pipe			
08	1	0	Pre-hydrolyzate cooler	STRM0302	145,536	145,536	1.00	$25,000	1999	$25,000	0.78	$25,000	2.2	$54,474	$25,000	481 ft2, parallel double pipe			
08	8	1	Hydrolyzer Bottoms Pump	STRM0302B	157,136	157,136	1.00	$121,690	1999	$1,095,210	0.6	$1,095,210	1.2	$1,314,252	$1,095,210	3000 GPM each Disc flow pumps, 245ft head	WP308	1,744.94	
07	4	0	Enzymatic Hydrolysis Tank	STRM0302B	750,000	375,000	0.50	$326,203	1999	$1,304,812	0.6	$860,855	2.0	$1,753,728	$860,855	375,000 gallons, 24 hour residence time, 2 side mounted agitators cone bottom, concrete base, bottom outlet through the concrete, 30° cone bottom			
		0							1999						$0				
										weighted averages:	0.61		1.60				1,996.61	-
a 307									Subtotal	$2,762,430		$2,318,473		$3,714,334	→ $2,323,604				
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)						$0	→ ($3,714,334)	is installed cost savings			
															$475,868	Cost Savings with SHCF (sum of A300 & A307 savings)			
00	11	0	Cellulase Fermentor Agitators	GALLONS	150,000	88,335	0.59	$200,000	1999	$2,200,000	0.51	$1,679,359	1.2	$2,062,956	$1,679,359	125 hp / agitator -- 1 agitator/vessel	WT400	559.28	1,373.10
00	11	0	Cellulase Fermentors	GALLONS	88,335	88,335	1.00	$179,952	1998	$1,979,472	0.71	$1,979,472	1.8	$3,526,602	$2,003,061	88335 gal, 2.5 psig, cooling coils in tank costed as H400, 40 ft. height, 20 ft. diameter			
01	3	0	1st Cellulase Seed Fermentor	STRM0433	2,790	932	0.33	$22,500	1997	$67,500	0.93	$24,343	2.0	$49,648	$24,824	11 gal / 15 psig / Jacketed / Agitator			
02	3	0	2nd Cellulase Seed Fermentor	STRM0433	2,790	932	0.33	$54,100	1997	$162,300	0.93	$58,531	2.0	$119,377	$59,689	221 gal / 15 psig / Jacketed /Agitator	WT402	119.82	149.78
03	3	0	3rd Cellulase Seed Fermentor	STRM0433	2,790	932	0.33	$282,100	1997	$846,300	0.93	$305,207	2.0	$622,482	$311,241	4417 gal / 15 psig / Jacketed /Agitator			
00	11	0	Cellulase Fermentation Cooler	QHX400EA	236,658	88,335	0.37	$34,400	1997	$378,400	0.78	$175,431	2.2	$389,815	$178,899	Immersible Coil 205 ft2 each			
01	5	1	Fermentor Air Compressor Package	STRM0440	80,455	80,455	1.00	$229,000	1999	$1,374,000	0.34	$1,374,000	1.3	$1,786,200	$1,374,000	7946 scfm each, 50 psig outlet, 1277 hp each, includes starter	WM401	5,108.00	5,370.92
00	1	1	Cellulase Transfer Pump	STRM0420	40,543	11,600	0.29	$9,300	1997	$18,600	0.79	$6,921	2.8	$19,706	$7,058	58 GPM / 100 ft. head	WP400	1.57	2.22
01	1	1	Cellulase Seed Pump	STRM0433	2,790	932	0.33	$12,105	1998	$24,210	0.7	$11,236	1.2	$13,644	$11,370	24 gpm / 1 hp	WP401	0.28	0.31
05	1	1	Media Pump	STRM0416	586	200	0.34	$8,300	1997	$16,600	0.79	$7,104	2.8	$20,227	$7,245	21 Gpm/100 Ft Head	WP405	0.09	0.03
20	1	1	Anti-foam Pump	STRM0417	227	79	0.35	$5,500	1997	$11,000	0.79	$4,761	2.8	$13,555	$4,855	4 gpm / 75 ft head	WP420	0.01	0.01
05	1	0	Media-Prep Tank	STRM0416	586	200	0.34	$64,600	1997	$64,600	0.71	$30,128	1.7	$51,467	$30,723	2083 Gal / 1.17 hp Agitator	WT402	0.65	85.84
20	1	0	Anti-foam Tank	STRM0417	227	79	0.35	$402	1998	$402	0.71	$189	1.7	$321	$192	67 gal, 3 hr. residence time			
										weighted averages:	0.61		1.52				5,789.71	6,982.21
00									Subtotal	$7,143,384		$5,656,682		$8,676,000	$5,692,516				
												from Pfpve.xls/0.45 equip.		$10,353,995	$1,677,994	Installed Cost Savings Using PureVision Enzyme Production Technology			

Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Install Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description	3442 WORK		NREL 900TPD
501	1	0	Beer Column	DIAM0501	4	2.29	0.56	$636,976	1996	$636,976	0.78	$402,792	2.1	$873,434	$415,921	7'6" DIA, 32 ACTUAL TRAYS, NUTTER V-GRID TRAYS			
502	1	0	Rectification Column	SS10S521	56,477	26,744	0.47	$525,800	1996	$525,800	0.78	$293,491	2.1	$636,421	$303,058	8' dia.(rect)., 4' dia. (strip) x 18" T.S., 60 act. Trays, 60% eff., Nutter V-Grid trays			
501	1	0	1st Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,676	1996	$435,676	0.68	$435,676	2.1	$944,742	$449,877	22278 sf each., 135 BTU/hr sf F			
502	1	0	2nd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.1	$944,685	$449,850	22278 sf., 170 BTU/hr sf F			
503	1	0	3rd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.1	$944,685	$449,850	22278 sf each., 170 BTU/hr sf F			
501	1	0	Beer Column Reboiler	QRFD0501	-7,863,670	-3,723,722	0.474	$158,374	1996	$158,374	0.68	$95,263	2.2	$214,340	$98,368	Fixed TS, 6602 sf, 31" dia., 20' long, 178 BTU/hr sf F			
502	1	0	Rectification Column Reboiler	QRFD0502	-987,427	-467,581	0.474	$29,600	1997	$29,600	0.68	$17,805	2.2	$39,563	$18,157	Thermosyphon, 512 sf, 15" dia., 20' long, 130 BTU/hr sf F			
504	1	0	Beer Column Condenser	QCND0501	277,820	131,557	0.474	$29,544	1996	$29,544	0.68	$17,771	2.2	$39,984	$18,350	Floating Head, 418 sf, 15" dia., 22' long, 92 BTU/hr sf F			
505	1	0	Rectification Column Condenser	QCND0502	4,905,410	2,322,883	0.474	$86,174	1996	$86,174	0.68	$51,834	2.2	$116,626	$53,524	Fixed TS, 1969 sf, 29" dia, 20' long, 157 BTU/hr sf F			
512	1	1	Beer Column Feed Interchange	AREA0512	909	430	0.474	$19,040	1996	$38,080	0.68	$22,905	2.2	$51,537	$23,652	431 sf, 200 BTU/hr sf F			
517	1	1	Evaporator Condenser	QHET0517	6,764,222	3,203,095	0.47	$121,576	1996	$243,152	0.68	$146,257	2.2	$329,077	$151,024	Fixed TS, 3906 sf, 29" dia., 20' long, 220 BTU/hr sf F			
503	1	0	Molecular Sieve (9 preces)	STRM0515	20,491	9,703	0.47	$2,700,000	1998	$2,700,000	0.7	$1,599,964	1.0	$1,619,030	$1,619,030	Superheater, twin mole sieve columns, product cooler, condenser, pumps, vacuum source.	WM503	55.00	55.00
501	1	1	Beer Column Bottoms Pump	PS01FLOW	5,053	2,200	0.44	$42,300	1997	$84,600	0.79	$43,861	2.8	$124,881	$44,728	2200 gpm, 150 ft head	WP501	84.65	118.68
503	1	1	Beer Column Reflux Pump	QCND0501	277,820	131,557	0.47	$1,357	1998	$2,714	0.79	$1,504	2.8	$4,248	$1,522	6 gpm, 140 ft head	WP503	0.22	0.51
504	1	1	Rectification Column Bottoms Pump	STRM0516	31,507	15,530	0.49	$4,916	1998	$9,832	0.79	$5,622	2.8	$15,884	$5,689	76 gpm, 158 ft head	WP504	2.80	3.46
505	1	1	Rectification Column Reflux Pump	QCND0502	4,906,301	2,323,304	0.47	$4,782	1998	$9,564	0.79	$5,299	2.8	$14,970	$5,362	207 gpm, 110 ft head	WP505	5.14	12.77
511	2	1	1st Effect Pump	STRM0525	278,645	133,617	0.48	$19,700	1997	$59,100	0.79	$33,069	2.8	$94,155	$33,723	1137 gpm each, 110 ft head	WP511	67.89	80.57
512	1	1	2nd Effect Pump	STRM0528	91,111	45,390	0.50	$13,900	1997	$27,800	0.79	$16,032	2.8	$45,646	$16,349	599 gpm, 110 ft head	WP512	17.37	19.12
513	2	1	3rd Effect Pump	STRM0531	48,001	23,814	0.50	$8,000	1997	$24,000	0.79	$13,795	2.8	$39,276	$14,068	196 gpm each, 110 ft head	WP513	12.54	10.26
514	1	1	Evaporator Condensate Pump	STRM534A	140,220	69,285	0.49	$12,300	1997	$24,600	0.79	$14,095	2.8	$40,131	$14,374	293 gpm, 125 ft head	WP514	9.20	12.43
515	1	1	Scrubber Bottoms Pump	STRM0551	15,377	7,427	0.48	$2,793	1998	$5,586	0.79	$3,143	2.8	$8,881	$3,181	31 gpm, 104 ft head	WP515	0.84	0.77
517	1	1	Kill Tank Bottoms Pump	STRM0518	5,053	660	0.13	$42,300	1997	$84,600	0.79	$16,944	2.8	$48,242	$17,279	660gpm, 72 ft head	WP517	12.19	-
503	1	0	Beer Column Reflux Drum	QCND0501	277,820	131,557	0.47	$11,900	1997	$11,900	0.93	$5,938	1.7	$10,144	$6,055	164 gal, 15 min res. Time, 50% wv, 2'6" dia., 5' long, 25 psig			
505	1	0	Rectification Column Reflux Drum	QCND0502	4,906,301	2,323,304	0.47	$45,600	1997	$45,600	0.72	$26,621	1.7	$45,476	$27,147	6225 gal, 15 min res time, 50% wv, 7' dia, 22' long, 25 psig			
512	1	0	Vent Scrubber	STRM0523	18,523	9,788	0.53	$99,000	1998	$99,000	0.78	$60,197	1.7	$102,043	$60,915	5' dia x 25' high, 4 stages, plastic Jaeger Tri-Packing			
513	1	0	Kill Tank	STRM0518	149,897	149,897	1.00	$99,920	1999	$99,920	0.78	$99,920	1.7	$167,384	$99,920	18 psig, 30 min. res. time			
										weighted averages:	0.72		1.71				267.85	313.57
00									Subtotal	$6,343,492		$4,301,097		$7,515,486	$4,400,972				
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)					1.7	$6,765,614	($749,872)	is installed cost savings			
601	1	0	Lignin conveyor	STRM0601B	225,140	225,140	1.00	$31,700	1997	$31,700	0.6	$31,700	1.5	$49,832	$ 32,327	14" dia, 100' long	WC109	21.50	
513	1	0	Syrup Sprayer	STRM0531	22,372	22,372	1.00	$1,000	1999	$1,000	0.3	$1,000	1.2	$1,200	$1,000	100 GPM syrup sprayer			
514	1	0	Lignin Loadout	STRM0601A	63,778	0	0.00	$41,200	1999	$41,200	0.3	$0	1.0	$0	$0	245 GPM @ 20.6% insoluble solids			
615	1	0	Equalization Basin	STRM0830	98,267	102,204	1.04	$350,000	1999	$350,000	0.79	$361,031	1.0	$361,031	$361,031	no less than 500,000 gal., above-ground bolted tank with cover, including foundations, pumps and controls	WM615	1,077.21	-
616	1	0	Anaerobic Digestion System	STRM0830	98,267	102,204	1.04	$3,200,000	1999	$3,200,000	0.79	$3,300,852	1.0	$3,300,852	$3,300,852	500,000 gal., includes site work, foundations, reactors and ancillary equipment			
617	1	0	Aerobic Digestion System	STRM0830	98,267	102,204	1.04	$4,300,000	1999	$4,300,000	0.79	$4,435,520	1.0	$4,435,520	$4,435,520	four-350,000 gal. Sequencing Batch Reactors, 48,000 lbs/day of O_2 transfer capability, de-nitrification facilities, aeration and mixing requires approximately 1,400 horsepower			
618	1	0	Pressure Sand Filters	STRM0830	98,267	102,204	1.04	$280,000	1999	$280,000	0.79	$288,825	1.0	$288,825	$288,825	400 ft^2 of filtration surface area, includes the engineering and legal cost to acquire an NPDES permit			
630	1	1	Recycle Water Pump	STRM0602	179,446	84,120	0.47	$10,600	1997	$21,200	0.79	$11,652	2.8	$33,175	$11,882	370 gpm, 150ft head	WP630	14.75	-
601	2	0	Beer Column Bottoms Centrifuge	CENTFLOW	404	300	0.74	$659,550	1998	$1,319,100	0.6	$1,103,371	1.2	$1,339,824	$1,116,520	requires 540gpm duty, 2 @ 300 gpm and 410 hp each	WS601	489.18	400.03
630	1	0	Recycled Water Tank	STRM0602	179,446	84,120	0.47	$14,515	1998	$14,515	0.745	$8,254	1.7	$13,992	$8,353	7410 gal, 20 min. res., 2.5 psig, 9.5ft diam. x 14.25ft			
										weighted averages:	0.76		1.03				1,602.64	690.39
00									Subtotal	$9,558,715		$9,542,206		$9,824,251	$9,556,310				
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)					1.3	$5,167,342	($4,656,910)	is installed cost savings			

quip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost In Base Year	Install Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description	3442 WORK		NREL 900TPD
03	1	1	Sulfuric Acid Pump	STRM0710	1,647	1,912	1.16	$8,000	1997	$16,000	0.79	$16,001	2.8	$51,253	$18,357	215 gpm, 150ft head	WP703	0.09	0.09
07	1	1	Antifoam Store Pump	STRM0417	227	79	0.35	$5,700	1997	$11,400	0.79	$4,934	2.8	$14,048	$5,031	0.5 gpm, 92 ft head	WP707	0.01	0.01
20	1	1	CSL Pump	STRM0735	2,039	859	0.42	$8,800	1997	$17,600	0.79	$8,889	2.8	$25,308	$9,065	182 gpm, 150ft head	WP720	0.15	0.18
03	1	0	Sulfuric Acid Storage Tank	STRM0710	1,647	1,912	1.16	$42,500	1997	$42,500	0.51	$45,860	1.8	$82,338	$46,767	20,000 gal, 240 hr supply, 90% wv, 12ft diam. x 24 ft, atmospheric			
07	1	0	Antifoam Storage Tank	STRM0417	227	227	1.00	$14,400	1997	$14,400	0.71	$14,400	1.7	$24,600	$14,685	12,000 gal, 27 day supply, 10.5ft diam. X 18.5ft			
20	1	0	CSL Storage Tank	STRM0735	2,039	859	0.42	$88,100	1997	$88,100	0.79	$44,495	1.7	$76,011	$45,375	30160 gal, 90% wv, 120 supply, 14.3ft diam. X 25 ft			
										weighted averages:	0.72		1.96					0.25	0.28
00									Subtotal	$190,000		$136,579		$273,557	$139,279				
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)					1.5	$1,220,544	$946,987	is installed cost savings			
803	1	0	Boiler with Superheater	STRM0815 + 216	200,000	200,000	1.00	$1,590,000	1999	$1,590,000	0.7	$1,590,000	1.3	$2,067,000	$1,590,000	200,000 #/hr running @ 171,488 #/hr; with 40,000 #/hr 160° superheat; 132,000#/hr 390° sat. @ 205 psig	WM803	75.60	75.60
820	1	0	Hot process water softener system	STRM0811B	229,386	45,003	0.20	$1,383,300	1999	$1,383,300	0.6	$520,623	1.2	$624,748	$520,623	200 gpm			
830	1	0	Hydrazine Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps	WM830	10.00	10.00
832	1	0	Ammonia Addition Pkg	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps	WM832	10.00	10.00
834	1	0	Phosphate Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps	WM834	10.00	10.00
04	2	1	Condensate Pump	STRM811A	249,633	38,798	0.16	$7,100	1997	$21,300	0.79	$4,894	4.6	$22,958	$4,991	130 gpm, 150' head	WP804	9.21	7.66
24	2	1	Deaerator Feed Pump	STRM811A	196,000	38,798	0.20	$9,500	1997	$28,500	0.79	$7,927	8.3	$67,097	$8,084	180 gpm, 115' head	WP824	4.89	2.27
26	4	1	BFW Pump	STRM0813	207,310	80,536	0.39	$52,501	1998	$262,505	0.79	$124,377	1.4	$176,203	$125,859	310 gpm, 2740' head	WP826	400.99	399.04
28	1	1	Blowdown Pump	STRM0821	6,600	2,699	0.41	$5,100	1997	$10,200	0.79	$5,032	6.4	$32,842	$5,132	12 gpm, 150' head	WP828	0.42	0.93
30	1	1	Hydrazine Transfer Pump	STRM813A	229,386	80,536	0.35	$5,500	1997	$11,000	0.79	$4,811	6.4	$31,402	$4,907	3 gpm, 75' head	WP830	0.05	0.01
04	1	0	Condensate Collection Tank	STRM811A	229,386	38,798	0.17	$7,100	1997	$7,100	0.71	$2,011	3.3	$6,766	$2,050	200 gal, 1.5 min. res. time			
24	1	0	Condensate Surge Drum	STRM811A	150,000	38,798	0.26	$49,600	1997	$49,600	0.72	$18,734	5.0	$95,523	$19,105	2100 gal., 6' diam. X 10', 15 psig, res. time 11 min.			
26	1	0	Deaerator	STRM0813	267,000	80,536	0.30	$165,000	1998	$165,000	0.72	$69,616	6.5	$457,896	$70,446	3030 gal., 15 psig, 10 min. res.			
28	1	0	Blowdown Flash Drum	STRM0821	6,550	2,699	0.41	$9,200	1997	$9,200	0.72	$4,859	7.3	$36,168	$4,955	210 gal., 2.5' diam. X 6', 50 psig 17 min. res.			
30	1	0	Hydrazine Drum	STRM813A	229,386	80,536	0.35	$12,400	1997	$12,400	0.93	$4,685	7.0	$33,440	$4,777	138 gal, 3.75' x 1.25' diam., 10 psig			
										weighted averages:	0.67		1.54					521.16	515.51
00									Subtotal	$3,607,105		$2,387,986		$3,684,612	$2,393,497				
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)					1.1	$23,046,972	$19,362,360	is installed cost savings			
902	1	0	Cooling Tower System	QCWCAPIT	41,100,000	12,955,985	0.32	$1,659,000	1998	$1,659,000	0.78	$674,181	1.2	$818,659	$682,216	40,000 gpm, 185.4MM BTU/hr	WM902	298.85	306.51
04	1	0	Plant Air Compressor	STRM0101	159,950	159,950	1.00	$60,100	1997	$60,100	0.34	$60,100	1.3	$79,675	$61,288	450 cfm, 125 psig outlet	WM904	186.40	186.40
08	1	0	Chilled Water Package	QCHLWCAP	5,040,000	2,268,000	0.45	$380,000	1997	$380,000	0.8	$200,610	1.2	$245,492	$204,577	1000 ton, 600kW	WM908	600.00	507.11
10	1	0	CIP System	STRM0914	63	28	0.45	$95,000	1995	$95,000	0.6	$58,837	1.2	$73,021	$60,851	designed by Delta-T, (est 0.2 kW)	WM910	0.20	-
02	1	1	Cooling Water Pumps	STRM0940	18,290,000	5,553,791	0.30	$332,300	1997	$664,600	0.79	$259,201	2.8	$737,993	$264,326	12300 gpm, 70ft head			
12	1	1	Make-up Water Pump	STRM0904	244,160	82,445	0.34	$10,800	1997	$21,600	0.79	$9,151	2.8	$26,084	$9,343	370 gpm, 75ft head	WP912	7.32	8.00
14	1	1	Process Water Circulating Pump	STRM0905	352,710	111,503	0.32	$11,100	1997	$22,200	0.79	$8,938	2.8	$25,449	$9,115	745 gpm, 75ft head	WP914	14.78	22.38
04	1	1	Instrument Air Dryer	STRM0101	159,950	71,977	0.45	$15,498	1999	$30,996	0.6	$19,197	1.3	$24,956	$19,197	134 scfm air dryer, -40F Dewpoint	WS601	4.91	4.91
04	1	0	Plant Air Receiver	STRM0101	159,950	53,316	0.33	$13,000	1997	$13,000	0.72	$5,884	1.7	$10,069	$6,011	300 gal., 200 psig			
14	1	0	Process Water Tank	STRM0905	352,710	111,503	0.32	$195,500	1997	$195,500	0.51	$108,663	1.8	$195,095	$110,811	234360 gal, 8hr res. time			
										weighted averages:	0.75		1.57			400 gpm well pump, 500ft head	53.16	1,165.62	1,035.31
a 900									Subtotal	$3,141,996		$1,404,783		$2,236,491	$1,427,733		Total kW	12,893	11,177
								2000tpd x .45 (current year cost with area weighted-average scale exponent applied)					1.3	$2,895,441	$658,949	is installed cost savings			

3442 PLANT TOTAL:	$57,333,793	$43,406,643	$61,054,640
45% NREL TOTAL:			$75,675,432
SAVINGS:			$14,620,792
			19.53%

	Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Instal. Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description
-P100-A201	A-201	1	0	In-line Sulfuric Acid Mixer	STRM0214	55,308	23,725	0.43	$1,900	1997	$1,900	0.48	$1,266	1.23	$1,585	$1,291	Static Mixer, 110 gpm total flow
-P100-A202	A-202	1	0	In-line NH3 Mixer	STRM0244	53,630	18,317	0.34	$1,500	1997	$1,500	0.48	$896	1.23	$1,122	$913	Static Mixer, 82 gpm total flow
-P100-A203	A-209	1	0	Overliming Tank Agitator	STRM0228	167,050	102,608	0.61	$19,800	1997	$19,800	0.51	$15,442	1.23	$19,345	$15,748	Top Mounted, 1800 rpm, 15 hp
-P100-A203	A-224	1	0	Reacidification Tank Agitator	STRM0239	167,280	102,752	0.61	$65,200	1997	$65,200	0.51	$50,851	1.23	$63,702	$51,857	Top-Mounted, 1800 rpm, 54 hp
-P100-A202	A-232	1	0	Reslurrying Tank Agitator	STRM0250	358,810	167,795	0.47	$36,000	1997	$36,000	0.51	$28,432	1.23	$30,606	$24,915	Top-Mounted, 1800 rpm, 25 hp
-P100-A203	A-235	1	0	In-line Acidification Mixer	STRM0236	164,570	101,104	0.61	$2,600	1997	$2,600	0.48	$2,058	1.23	$2,578	$2,099	Static-Mixer, 440 gpm total flow
-P100-A302	A-300	8	0	Fermentor Agitators	GALLONS	962,651	750,000	0.78	$19,676	1996	$157,408	0.51	$138,592	1.23	$175,799	$143,110	Side Mounted, 2 per vessel, 60 hp each, 0.15 hp/1000 gal
-P100-A301	A-301	1	0	Seed Hold Tank Agitator	STRM0304	41,777	17,529	0.42	$12,551	1996	$12,551	0.51	$8,060	1.23	$10,223	$8,322	Top Mounted, 1800 rpm, 10 hp, 0.1 hp/1000 gal
-P100-A301	A-304	2	0	4th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$11,700	1997	$23,400	0.51	$15,026	1.23	$18,824	$15,323	Top Mounted, 1800 rpm, 3 hp, 0.3 hp/1000 gal
-P100-A301	A-305	2	0	5th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$10,340	1996	$20,680	0.51	$13,280	1.23	$16,845	$13,713	Top Mounted, 1800 rpm, 9 hp, 0.1 hp/1000 gal
-P100-A302	A-306	1	0	Beer Well Agitator	STRM0502	381,700	173,737	0.46	$10,100	1997	$10,100	0.51	$6,761	1.23	$8,469	$6,894	Top Mounted, 1800 rpm, 2 hp, 0.3 hp/1000 gal
-P100-A307	A-307	8	0	Enzymatic Hydrolysis Tank Agitators	STRM0302B	157,136	157,136	1.00	$19,676	1996	$157,408	0.51	$157,408	1.23	$199,666	$162,539	two side mounted 75 hp agitators / tank, 0.4hp/1000 gal.
-P100-A402	A-400	11	0	Cellulase Fermentor Agitators	GALLONS	150,000	88,335	0.59	$200,000	1999	$2,200,000	0.51	$1,679,359	1.23	$2,062,956	$1,679,359	125 hp / agitator -- 1 agitator/vessel
		39	**0**	**39**										**1.23**	**$ 2,611,720**	**$ 66,967**	
		sum	sum	total										avg.	sum	avg. (installed)	
-P100-A101	C-101	1	0	Bale conveyor	AREA0100	154	170	1.11	$15,000	1999	$15,000	0.6	$15,927	1.54	$24,551	$ 15,927	wire mesh conveyor 60" wide 20' long
-P100-A101	C-102	1	0	Radial Stacker Conveyor	AREA0100	154	170	1.11	$159,830	1999	$159,830	0.6	$169,708	1.54	$261,604	$ 169,708	16 degree, 36" x 200' radial stacker, 750 ton/hr, 75 HP
-P100-A101	C-103	1	0	Breaker Infeed Belt	AREA0100	154	170	1.11	$49,500	1999	$49,500	0.6	$52,559	1.54	$81,020	$ 52,559	84" x 35' rubber belt cleated infeed conveyor, 10 HP, TEFC drive motor with guard
-P100-A101	C-104	1	0	1st Shredder Conveyor	AREA0100	154	170	1.11	$25,650	1999	$25,650	0.6	$27,235	1.54	$41,983	$ 27,235	60" wide x 25' long, 10 HP, TEFC drive with guard
-P100-A101	C-105	1	0	1st Infeed Belt	AREA0100	154	170	1.11	$38,500	1999	$38,500	0.6	$40,879	1.54	$63,015	$ 40,879	60" wide x 30' long, 10 HP, TEFC drive with guard
-P100-A101	C-106	1	0	2nd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.54	$48,285	$ 31,323	48" wide x 20' long, 7.5 HP, TEFC drive with guard
-P100-A101	C-107	1	0	2nd Infeed Belt	AREA0100	154	170	1.11	$27,500	1999	$27,500	0.6	$29,200	1.54	$45,011	$ 29,200	48" wide x 30' long, 5 HP, TEFC drive with guard
-P100-A101	C-108	1	0	3rd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.54	$48,285	$ 31,323	48" wide x 20' long, 10 HP, TEFC drive with guard
-P100-A101	C-109	1	0	Feed Screw Conveyor	AREA0100	225,140	562,850	2.50	$31,700	1997	$31,700	0.6	$54,932	1.54	$86,351	$ 56,018	14" dia. 250' long
-P100-A201	C-201	1	0	Hydrolyzate Screw Conveyor	STRM0220	225,140	101,493	0.45	$59,400	1997	$59,400	0.78	$31,908	1.54	$50,158	$32,539	18" dia. 33' long, 3420 cfh max flow, 23 hp
-P100-A202	C-202	1	0	Wash Solids Screw Conveyor	STRM0225	196,720	165,453	0.84	$23,700	1997	$23,700	1.00	$19,933	1.54	$31,334	$20,327	18" dia. 16' long, 3420 cfh max flow
-P100-A203	C-225	1	0	Lime Solids Feeder	none				$3,900	1997	$3,900	1	$3,900	1.54	$6,131	$3,977	6" dia., 63 cfh, 3150 lb/hr max flow
-P100-A601	C-601	1	0	Lignin conveyor	STRM0601B	225,140	225,140	1.00	$31,700	1997	$31,700	0.6	$31,700	1.54	$49,832	$32,327	14" dia. 100' long
		13	**0**	**13**										**1.54**	**$ 837,560**	**$ 64,428**	
		sum	sum	total										avg.	sum	avg. (installed)	
-P100-A501	D-501	1	0	Beer Column	DIAMD501	4	2.29	0.56	$636,976	1996	$636,976	0.78	$402,792	2.10	$873,434	$415,921	7'6" DIA, 32 ACTUAL TRAYS, NUTTER V-GRID TRAYS
-P100-A502	D-502	1	0	Rectification Column	S510S521	56,477	26,744	0.47	$525,800	1996	$525,800	0.78	$293,491	2.10	$636,421	$303,058	8' dia.(rect)., 4' dia. (strip) x 18" T.S., 60 act. Trays, 60% eff., Nutter V-Grid trays
-P100-A504	E-501	1	0	1st Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,676	1996	$435,676	0.68	$435,676	2.10	$944,742	$449,877	22278 sf each , 135 BTU/hr sf F
-P100-A504	E-502	1	0	2nd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.10	$944,685	$449,850	22278 sf., 170 BTU/hr sf F
-P100-A504	E-503	1	0	3rd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.10	$944,685	$449,850	22278 sf each., 170 BTU/hr sf F
		5	**0**	**5**										**2.10**	**$ 4,343,968**	**$ 858,794**	
		sum	sum	total										avg.	sum	avg. (installed)	
-P100-A302	F-300	4	0	Fermentors	GALLONS	750,000	750,000	1.00	$326,203	1999	$1,304,812	0.71	$1,304,812	1.76	$2,297,260	$1,304,812	750,000 gal. each, 2 day residence total, 90% wv, API, atmospheric, 50' f x 51'
-P100-A301	F-301	2	0	1st Fermentation Seed Fermentor	None		0	0.45	$14,700	1997	$29,400	0.93	$13,991	2.80	$39,948	$14,267	9 gal, jacketed, agitated, 1' dia., 1.5' high, 15 psig
-P100-A301	F-302	2	0	2nd Fermentation Seed Fermentor	None		0	0.45	$32,600	1997	$65,200	0.93	$31,027	2.80	$88,592	$31,640	90 gal., jacketed, agitated, 2' 3" dia., 3' high, 2.5 psig
-P100-A301	F-303	2	0	3rd Fermentation Seed Fermentor	None		0	0.45	$81,100	1997	$162,200	0.93	$77,186	2.80	$220,394	$78,712	900 gal., jacketed, agitated, 5' dia, 6.5' high, 2.5 psig
-P100-A301	F-304	2	0	4th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$39,500	1997	$79,000	0.93	$35,225	1.68	$60,174	$35,921	9000 gal., 9' dia x 19' high, atmospheric
-P100-A301	F-305	2	0	5th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$147,245	1998	$294,490	0.51	$189,107	1.76	$336,910	$191,360	90000 gal., API, atmospheric 25'f x 25'
-P100-A402	F-400	11	0	Cellulase Fermentors	GALLONS	88,335	88,335	1.00	$179,952	1998	$1,979,472	0.71	$1,979,472	1.76	$3,526,602	$2,003,061	88335 gal, 2.5 psig, cooling coils in tank costed as H400, 40 ft. height, 20 ft. diameter
-P100-A401	F-401	3	0	1st Cellulase Seed Fermentor	STRM0433	2,790	932	0.33	$22,500	1997	$67,500	0.93	$24,343	2.00	$49,648	$24,824	11 gal / 15 psig / Jacketed / Agitator
-P100-A401	F-402	3	0	2nd Cellulase Seed Fermentor	STRM0433	2,790	932	0.33	$54,100	1997	$162,300	0.93	$58,531	2.00	$119,377	$59,689	221 gal / 15 psig / Jacketed./Agitator
-P100-A401	F-403	3	0	3rd Cellulase Seed Fermentor	STRM0433	2,790	932	0.33	$282,100	1997	$846,300	0.93	$305,207	2.00	$622,482	$311,241	4417 gal / 15 psig / Jacketed./Agitator
		34	**0**	**34**										**2.14**	**$ 7,361,387**	**$ 216,511**	
		sum	sum	total										avg.	sum	avg. (installed)	

D	Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Instal. Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description
D-P100-A202	H-200	1	0	Hydrolyzate Cooler	AREA0200	1,988	895	0.45	$45,000	1997	$45,000	0.51	$29,947	2.18	$66,543	$30,539	Fixed Tube Sheet, 900 sf, 20" dia. X 20' long
D-P100-A201	H-201	1	1	Beer Column Feed Economizer	AREA0201	5,641	5,641	1.00	$139,350	1999	$278,700	0.68	$278,700	2.18	$607,278	$278,700	TEMA type AES shell and tube 5641 sf, 42" dia x 20' long
D-P100-A302	H-300	4	1	Fermentation Cooler	QHX300EA	67,820	25,053	0.37	$4,000	1997	$20,000	0.78	$9,198	2.18	$20,438	$9,380	4 exchangers at 221 sf, U=300 BTU/hr sf F LMTD = 22.9°F plate and frame
D-P100-A301	H-301	1	0	Fermentation Seed Hydrolyzate Cooler	AREA0301	773	318	0.41	$15,539	1998	$15,539	0.78	$7,778	2.18	$17,151	$7,871	348 sf, 300 BTU/hr sf F
D-P100-A302	H-302	1	0	Fermentation Pre-Cooler	AREA0302	3,765	828	0.22	$25,409	1998	$25,409	0.78	$7,797	2.18	$17,193	$7,890	828 sf total, plate and frame
D-P100-A301	H-304	1	0	4TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$3,300	1997	$3,300	0.83	$1,580	1.20	$1,934	$1,611	12 sf, 1" sch 40 pipe, 105 BTU/hr sf F
D-P100-A301	H-305	1	0	5TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$18,800	1997	$18,800	0.98	$7,881	1.20	$9,644	$8,037	138 sf, 2" sch 40 pipe, 92 BTU/hr sf F
D-P100-A307	H-307	12	0	Enzymatic Hydrolysis Tank Heater	STRM0302B	157,136	157,136	1.00	$15,000	1999	$180,000	0.78	$180,000	2.18	$392,214	$180,000	65 ft2 double pipe
D-P100-A307	H-308	1	0	Pre-hydrolyzate cooler	STRM0302	145,536	145,536	1.00	$25,000	1999	$25,000	0.78	$25,000	2.18	$54,474	$25,000	481 ft2, parallel double pipe
D-P100-A402	H-400	11	0	Cellulase Fermentation Cooler	QHX400EA	236,668	88,335	0.37	$34,400	1997	$378,400	0.78	$175,431	2.18	$389,815	$178,899	Immersible Coil 205 ft2 each
D-P100-A501	H-501	1	0	Beer Column Reboiler	QRFD0501	-7,863,670	-3,723,722	0.474	$158,374	1996	$158,374	0.68	$95,263	2.18	$214,340	$98,368	Fixed TS, 6602 sf, 31" dia., 20' long, 178 BTU/hr sf F
D-P100-A502	H-502	1	0	Rectification Column Reboiler	QRFD0502	-987,427	-467,581	0.474	$29,600	1997	$29,600	0.68	$17,805	2.18	$39,563	$18,157	Thermosyphon, 512 sf, 15" dia., 20' long, 130 BTU/hr sf F
D-P100-A501	H-504	1	0	Beer Column Condenser	QCND0501	277,820	131,557	0.474	$29,544	1996	$29,544	0.68	$17,771	2.18	$39,984	$18,350	Floating Head, 418 sf, 15" dia., 22' long, 92 BTU/hr sf F
D-P100-A502	H-505	1	0	Rectification Column Condenser	QCND0502	4,905,410	2,322,883	0.474	$86,174	1996	$86,174	0.68	$51,834	2.18	$116,626	$53,524	Fixed TS, 1969 sf, 29" dia, 20' long, 157 BTU/hr sf F
D-P100-A501	H-512	1	1	Beer Column Feed Interchange	AREA0512	909	430	0.474	$19,040	1996	$38,080	0.68	$22,905	2.18	$51,537	$23,652	431 sf, 200 BTU/hr sf F
D-P100-A504	H-517	1	1	Evaporator Condenser	QHET0517	6,764,222	3,203,095	0.47	$121,576	1996	$243,152	0.68	$146,257	2.18	$329,077	$151,024	Fixed TS, 3906 sf, 29" dia., 20' long, 220 BTU/hr sf F
		40	**4**	**44**										**2.06**	**$ 2,367,812**	**$ 53,814**	
		sum	sum	total										avg.	sum	avg. (installed)	
D-P100-A101	M-101	2	0	Truck Scale	AREA0100	96	72	0.75	$10,000	1999	$20,000	0.6	$16,829	1.50	$25,244	$ 16,829	96 deliveries /scale/12hr
D-P100-A101	M-102	1	0	Receiving Pad	AREA0100	250,000	250,000	1.00	$2,083,500	1999	$2,083,500	0.6	$2,083,500	1.00	$2,083,500	$ 2,083,500	250,000 ft2 concrete pad, 9" thick with drainage
D-P100-A101	M-103	6	1	Front End Loader	AREA0100	159,948	159,948	1.00	$156,000	1998	$1,092,000	0.6	$1,092,000	1.20	$ 1,326,016	$ 1,105,013	run on gasoline
D-P100-A101	M-104	3	0	Bale Breaker	AREA0100	154	170	1.11	$250,000	1999	$750,000	0.6	$796,352	1.20	$955,622	$ 796,352	30 HP each
D-P100-A101	M-105	1	0	Primary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.20	$135,444	$ 112,870	250 HP, 1200 rpm, hammermill
D-P100-A101	M-106	1	0	Secondary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.50	$169,304	$ 112,870	250 HP, 1200 rpm, hammermill
D-P100-A101	M-107	1	0	Shred Bunker	AREA0100	600,000	600,000	1.00	$700,000	1999	$700,000	0.6	$700,000	1.00	$700,000	$ 700,000	200x100x30ft bunker with three walls, 3 days shred storage
D-P100-A101	M-108	1	0	Storm Runoff Pond	AREA0100	1,747,767	1,747,767	1.00	$51,198	1998	$51,198	0.6	$51,198	1.00	$51,198	$ 51,808	200 x 150 x 8 ft, 240,000ft3
D-P100-A201	M-202	1	0	Prehydrolysis Reactor	STRM0217	270,034	121,514	0.45	$12,461,841	1998	$12,461,841	0.78	$6,684,746	1.50	$10,146,612	$6,764,408	Vertical Screw, 10 min residence time
D-P100-A402	M-401	5	1	Fermentor Air Compressor Package	STRM0440	80,455	80,455	1.00	$229,000	1999	$1,374,000	0.34	$1,374,000	1.30	$1,786,200	$1,374,000	7946 scfm each, 50 psig outlet, 1277 hp each, includes starter
D-P100-A503	M-503	1	0	Molecular Sieve (9 pieces)	STRM0515	20,491	9,703	0.47	$2,700,000	1998	$2,700,000	0.7	$1,599,964	1.00	$1,619,030	$1,619,030	Superheater, twin mole sieve columns, product cooler, condenser, pumps, vacuum source
D-P100-A601	M-613	1	0	Syrup Sprayer	STRM0531	22,372	22,372	1.00	$1,000	1999	$1,000	0.3	$1,000	1.20	$1,200	$1,000	100 GPM syrup sprayer
D-P100-A601	M-614	1	0	Lignin Loadout	STRM0601A	63,778	0	0.00	$41,200	1999	$41,200	0.3	$0	1.00	$0	$0	245 GPM @ 20.6% insoluble solids
D-P100-A602	M-615	1	0	Equalization Basin	STRM0830	98,267	102,204	1.04	$350,000	1999	$350,000	0.79	$361,031	1.00	$361,031	$361,031	no less than 500,000 gal., above-ground bolted tank with cover, including foundations, pumps and controls
D-P100-A602	M-616	1	0	Anaerobic Digestion System	STRM0830	98,267	102,204	1.04	$3,200,000	1999	$3,200,000	0.79	$3,300,852	1.00	$3,300,852	$3,300,852	500,000 gal., includes site work, foundations, reactors and ancillary equipment
D-P100-A602	M-617	1	0	Aerobic Digestion System	STRM0830	98,267	102,204	1.04	$4,300,000	1999	$4,300,000	0.79	$4,435,520	1.00	$4,435,520	$4,435,520	four-350,000 gal. Sequencing Batch Reactors, 48,000 lbs/day of O2 transfer capability, de-nitrification facilities, aeration and mixing requires approximately 1,400 horsepower
D-P100-A602	M-618	1	0	Pressure Sand Filters	STRM0830	98,267	102,204	1.04	$280,000	1999	$280,000	0.79	$288,825	1.00	$288,825	$288,825	400 ft2 of filtration surface area, includes the engineering and legal cost to acquire an NPDES permit
D-P100-A801	M-803	1	0	Boiler with Superheater	STRM0815 + 216	200,000	200,000	1.00	$1,590,000	1999	$1,590,000	0.7	$1,590,000	1.30	$2,067,000	$1,590,000	200,000 #/hr running @ 171,488 #/hr; with 40,000 #/hr 160o superheat; 132,000#/hr 390o sat. @ 205 psig
D-P100-A802	M-820	1	0	Hot process water softener system	STRM0811B	229,386	45,003	0.20	$1,383,300	1999	$1,383,300	0.6	$520,623	1.20	$624,748	$520,623	200 gpm
D-P100-A803	M-830	1	0	Hydrazine Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.00	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps
D-P100-A803	M-832	1	0	Ammonia Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.00	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps
D-P100-A803	M-834	1	0	Phosphate Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.00	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps
D-P100-A901	M-902	1	0	Cooling Tower System	QCWCAPIT	41,100,000	12,955,985	0.32	$1,659,000	1998	$1,659,000	0.78	$674,181	1.20	$818,659	$682,216	40,000 gpm, 185.4MM BTU/hr
D-P100-A901	M-904	1	0	Plant Air Compressor	STRM0101	159,950	159,950	1.00	$60,100	1997	$60,100	0.34	$60,100	1.30	$79,675	$61,288	450 cfm, 125 psig outlet
D-P100-A901	M-908	1	0	Chilled Water Package	QCHLWCAP	5,040,000	2,268,000	0.45	$380,000	1997	$380,000	0.8	$200,610	1.20	$245,492	$204,577	1000 ton, 600kW
D-P100-A903	M-910	1	0	CIP System	STRM0914	63	28	0.45	$95,000	1995	$95,000	0.6	$58,837	1.20	$73,021	$60,851	designed by Delta-T, (est 0.2 kW)
		38	**2**	**40**										**1.15**	**$ 31,326,762**	**$ 783,169**	
		sum	sum	total										avg.	sum	avg. (installed)	

ID	Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Instal. Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description
D-P100-A201	P-201	1	1	Sulfuric Acid Pump	STRM0710	1,647	414	0.25	$4,800	1997	$9,600	0.79	$3,228	2.79	$9,190	$3,291	2 gpm, 245 ft. head
D-P100-A203	P-209	1	1	Overlimed Hydrolyzate Pump	STRM0228	167,050	102,698	0.61	$10,700	1997	$21,400	0.79	$14,561	2.79	$41,458	$14,849	448 gpm, 150 ft. head
D-P100-A203	P-222	1	1	Filtered Hydrolyzate Pump	STRM0230	162,090	101,614	0.63	$10,800	1997	$21,600	0.79	$14,936	2.79	$42,526	$15,231	448 gpm, 150 ft head
D-P100-A203	P-223	1	0	Lime Unloading Blower	STRM0227	547	337	0.62	$47,600	1998	$47,600	0.5	$37,340	1.40	$52,898	$37,785	3341 cfm, 6 psi, 10,024 lb/hr
D-P100-A202	P-224	1	1	Hydrolysis Feed Pump	STRM0250	160,000	167,795	1.05	$64,934	1999	$129,868	0.6	$133,628	1.20	$160,354	$133,628	740 gpm, 240 ft head
D-P100-A202	P-225	1	1	ISEP Elution Pump	STRM0243	52,731	18,005	0.34	$7,900	1997	$15,800	0.79	$6,761	2.79	$19,249	$6,894	104 gpm, 150 ft head
D-P100-A202	P-226	1	1	ISEP Reload Pump	STRM0246	164,080	100,802	0.61	$8,700	1997	$17,400	0.79	$11,841	2.79	$33,714	$12,075	445 gpm, 150 ft head
D-P100-A202	P-227	1	1	ISEP Hydrolyzate Feed Pump	STRM0221	160,290	98,157	0.61	$10,700	1997	$21,400	0.79	$14,526	2.79	$41,359	$14,814	432 gpm, 150 ft head
D-P100-A203	P-239	1	1	Reacidified Liquor Pump	STRM0239	167,280	102,752	0.61	$10,800	1997	$21,600	0.79	$14,698	2.79	$41,847	$14,988	450 gpm, 100 ft head
D-P100-A302	P-300	4	1	Fermentation Recirc./Transfer Pump	QHX300EA	67,737	55,505	0.82	$8,000	1997	$40,000	0.79	$34,177	2.79	$97,307	$34,852	844 gpm @ 150 ft sized based on heating rate
D-P100-A301	P-301	1	1	Fermentation Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$22,194	1998	$44,388	0.7	$24,168	1.40	$34,238	$24,456	280 gpm @ 150 ft head
D-P100-A301	P-302	2	0	Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$54,088	1998	$108,176	0.7	$58,898	1.40	$83,440	$59,600	504 gpm total, 252 gpm each, 100 ft head
D-P100-A302	P-306	1	1	Beer Transfer Pump	STRM0502	381,701	173,737	0.46	$17,300	1997	$34,600	0.79	$18,579	2.79	$52,899	$18,947	790 gpm each, 171 ft head
D-P100-A307	P-308	8	1	Hydrolyzer Bottoms Pump	STRM0302B	157,136	157,136	1.00	$121,690	1999	$1,095,210	0.6	$1,095,210	1.20	$1,314,252	$1,095,210	3000 GPM each Disc flow pumps, 245ft head
D-P100-A402	P-400	1	1	Cellulase Transfer Pump	STRM0420	40,543	11,600	0.29	$9,300	1997	$18,600	0.79	$6,921	2.79	$19,706	$7,058	58 GPM / 100 ft. head
D-P100-A401	P-401	1	1	Cellulase Seed Pump	STRM0433	2,790	932	0.33	$12,105	1998	$24,210	0.7	$11,236	1.20	$13,644	$11,370	24 gpm / 1 hp
D-P100-A402	P-405	1	1	Media Pump	STRM0416	586	200	0.34	$8,300	1997	$16,600	0.79	$7,104	2.79	$20,227	$7,245	21 Gpm/100 Ft Head
D-P100-A405	P-420	1	1	Anti-foam Pump	STRM0417	227	79	0.35	$5,500	1997	$11,000	0.79	$4,761	2.79	$13,555	$4,855	4 gpm / 75 ft head
D-P100-A501	P-501	1	1	Beer Column Bottoms Pump	P501FLOW	5,053	2,200	0.44	$42,300	1997	$84,600	0.79	$43,861	2.79	$124,881	$44,728	2200 gpm, 150 ft head
D-P100-A501	P-503	1	1	Beer Column Reflux Pump	QCND0501	277,820	131,557	0.47	$1,357	1998	$2,714	0.79	$1,504	2.79	$4,248	$1,522	6 gpm, 140 ft head
D-P100-A502	P-504	1	1	Rectification Column Bottoms Pump	STRM0516	31,507	15,530	0.49	$4,916	1998	$9,832	0.79	$5,622	2.79	$15,884	$5,689	76 gpm, 158 ft head
D-P100-A502	P-505	1	1	Rectification Column Reflux Pump	QCND0502	4,906,301	2,323,304	0.47	$4,782	1998	$9,564	0.79	$5,299	2.79	$14,970	$5,362	207 gpm, 110 ft head
D-P100-A504	P-511	2	1	1st Effect Pump	STRM0525	278,645	133,617	0.48	$19,700	1997	$59,100	0.79	$33,069	2.79	$94,155	$33,723	1137 gpm each, 110 ft head
D-P100-A504	P-512	1	1	2nd Effect Pump	STRM0528	91,111	45,390	0.50	$13,900	1997	$27,800	0.79	$16,032	2.79	$45,646	$16,349	599 gpm, 110 ft head
D-P100-A504	P-513	2	1	3rd Effect Pump	STRM0531	48,001	23,814	0.50	$8,000	1997	$24,000	0.79	$13,795	2.79	$39,276	$14,068	196 gpm each, 110 ft head
D-P100-A504	P-514	1	1	Evaporator Condensate Pump	STRM534A	140,220	69,285	0.49	$12,300	1997	$24,600	0.79	$14,095	2.79	$40,131	$14,374	293 gpm, 125 ft head
D-P100-A502	P-515	1	1	Scrubber Bottoms Pump	STRM0551	15,377	7,427	0.48	$2,793	1998	$5,586	0.79	$3,143	2.79	$8,881	$3,181	31 gpm, 104 ft head
D-P100-A501	P-517	1	1	Kill Tank Bottoms Pump	STRM0518	5,053	660	0.13	$42,300	1997	$84,600	0.79	$16,944	2.79	$48,242	$17,279	660gpm, 72 ft head
D-P100-A601	P-630	1	1	Recycle Water Pump	STRM0602	179,446	84,120	0.47	$10,600	1997	$21,200	0.79	$11,652	2.79	$33,175	$11,882	370 gpm, 150ft head
D-P100-A701	P-703	1	1	Sulfuric Acid Pump	STRM0710	1,647	1,912	1.16	$8,000	1997	$16,000	0.79	$18,001	2.79	$51,253	$18,357	215 gpm, 150ft head
D-P100-A701	P-707	1	1	Antifoam Store Pump	STRM0417	227	79	0.35	$5,700	1997	$11,400	0.79	$4,934	2.79	$14,048	$5,031	0.5 gpm, 92 ft head
D-P100-A701	P-720	1	1	CSL Pump	STRM0735	2,039	859	0.42	$8,800	1997	$17,600	0.79	$8,889	2.79	$25,308	$9,065	182 gpm, 150ft head
D-P100-A802	P-804	2	1	Condensate Pump	STRM811A	249,633	38,798	0.16	$7,100	1997	$21,300	0.79	$4,894	4.60	$22,958	$4,991	130 gpm, 150' head
D-P100-A802	P-824	2	1	Deaerator Feed Pump	STRM811A	196,000	38,798	0.20	$9,500	1997	$28,500	0.79	$7,927	8.30	$67,097	$8,084	180 gpm, 115' head
D-P100-A802	P-826	4	1	BFW Pump	STRM0813	207,310	80,536	0.39	$52,501	1998	$262,505	0.79	$124,377	1.40	$176,203	$125,859	310 gpm, 2740' head
D-P100-A802	P-828	1	1	Blowdown Pump	STRM0821	6,600	2,699	0.41	$5,100	1997	$10,200	0.79	$5,032	6.40	$32,842	$5,132	12 gpm, 150' head
D-P100-A803	P-830	1	1	Hydrazine Transfer Pump	STRM813A	229,386	80,536	0.35	$5,500	1997	$11,000	0.79	$4,811	6.40	$31,402	$4,907	3 gpm, 75' head
D-P100-A901	P-902	1	1	Cooling Water Pumps	STRM0940	18,290,000	5,553,791	0.30	$332,300	1997	$664,600	0.79	$259,201	2.79	$737,993	$264,326	12300 gpm, 70ft head
D-P100-A902	P-912	1	1	Make-up Water Pump	STRM0904	244,160	82,445	0.34	$10,800	1997	$21,600	0.79	$9,161	2.79	$26,084	$9,343	370 gpm, 75ft head
D-P100-A902	P-914	1	1	Process Water Circulating Pump	STRM0905	352,710	111,503	0.32	$11,100	1997	$22,200	0.79	$8,938	2.79	$25,449	$9,115	745 gpm, 75ft head
		58	38	96										2.90	$ 3,771,987	$ 39,292	
		sum	sum	total										avg.	sum	avg. (installed)	

D	Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Instal. Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description
D-P100-A202	S-202	3	0	Pre-IX Belt Filter Press	SOLD0220	57,000	57,000	1.00	$200,000	1998	$600,000	0.39	$600,000	1.40	$850,010	$607,150	Use 3 units for 45% of the flow as recommended by the vendor
D-P100-A202	S-221	1	0	ISEP	STRM0240	210,005	98,157	0.47	$2,058,000	1997	$2,058,000	0.33	$1,601,194	1.20	$1,959,422	$1,632,851	10 chambers (39" dia. X 84" high), 4" dia. Valve - Weak Base Resin
D-P100-A203	S-222	1	0	Hydroclone & Rotary Drum Filter	STRM0229	5,195	1,137	0.22	$165,000	1998	$165,000	0.39	$91,224	1.40	$129,235	$92,311	Hydrocyclone and Vacuum Filter for 453 gpm
D-P100-A203	S-227	1	0	LimeDust Vent Baghouse	STRM0227	548	337	0.61	$32,200	1997	$32,200	1	$19,778	1.50	$30,254	$20,169	3750 cfm, 625 sf, 6 cfm/sf
D-P100-A601	S-601	2	0	Beer Column Bottoms Centrifuge	CENTFLOW	404	300	0.74	$659,550	1998	$1,319,100	0.6	$1,103,371	1.20	$1,339,824	$1,116,520	requires 540gpm duty, 2 @ 300 gpm and 410 hp each
D-P100-A901	S-904	1	1	Instrument Air Dryer	STRM0101	159,950	71,977	0.45	$15,498	1999	$30,996	0.6	$19,197	1.30	$24,956	$19,197	134 scfm air dryer, -40F Dewpoint
		9	**1**	**10**										**1.33**	**$ 4,333,701**	**$ 433,370**	
		sum	sum	total										avg.	sum	avg. (installed)	
D-P100-A201	T-201	1	0	Sulfuric Acid Storage	STRM0710	1,647	860	0.52	$5,760	1996	$5,760	0.71	$3,633	1.68	$6,283	$3,751	2000 gal., 24 hr. residence time, 90% wv, 5.5ft diam. X 11ft
D-P100-A201	T-203	1	0	Blowdown Tank	STRM0217	270,300	121,514	0.45	$64,100	1997	$64,100	0.93	$30,475	1.68	$52,061	$31,078	7000 gal., 11' dia x 30' high, 10 min. res. time, 75% wv, 15 psig
D-P100-A203	T-209	1	0	Overliming Tank	STRM0228	167,050	102,608	0.61	$71,000	1997	$71,000	0.71	$50,232	1.76	$90,186	$51,225	29850 gal., 16' dia. X 32' high, 1 hr. res. time, 90% wv, 15 psig
D-P100-A203	T-220	1	0	Lime Storage Bin	STRM0227	548	548	1.00	$69,200	1997	$69,200	0.46	$69,200	1.76	$124,243	$70,568	4455 cf, 14' dia x 25' high, 1.5x rail car vol., atmospheric, 15 day storage max
D-P100-A203	T-224	1	0	Reacidification Tank	STRM0239	102,752	102,752	1.00	$111,889	1999	$111,889	0.51	$111,889	1.76	$196,992	$111,889	120,000 gal., 28' dia x 28' high, 4 hr. res. time, 90% wv, atmospheric
D-P100-A202	T-232	1	0	Slurrying Tank	STRM0250	358,810	167,795	0.47	$44,800	1997	$44,800	0.71	$26,117	1.76	$46,890	$26,633	11300 gal., 13' dia. X 25' high, 15 min. res. time, 90% wv
D-P100-A301	T-301	1	0	Fermentation Seed Hold Tank	STRM0304	41,777	17,529	0.42	$161,593	1998	$161,593	0.51	$103,767	1.76	$184,870	$105,003	105000 gal., API atmospheric
D-P100-A302	T-306	1	0	Beer Well	STRM0502	129,000	183,467	1.42	$111,889	1999	$111,889	0.51	$133,906	1.76	$235,756	$133,906	192,518 gal., 32' dia x 32' high, 4 hr. res. time, 95% wv, atmospheric
D-P100-A307	T-307	4	0	Enzymatic Hydrolysis Tank	STRM0302B	750,000	375,000	0.50	$326,203	1999	$1,304,812	0.6	$860,855	2.04	$1,753,728	$860,855	375,000 gallons, 24 hour residence time, 2 side mounted agitators cone bottom, concrete base, bottom outlet through the concrete, 30o cone bottom
D-P100-A302	T-405	1	0	Media-Prep Tank	STRM0416	586	200	0.34	$64,600	1997	$64,600	0.71	$30,128	1.68	$51,467	$30,723	2083 Gal / 1.17 hp Agitator
D-P100-A402	T-420	1	0	Anti-foam Tank	STRM0417	227	79	0.35	$402	1998	$402	0.71	$189	1.68	$321	$192	67 gal, 3 hr. residence time
D-P100-A501	T-503	1	0	Beer Column Reflux Drum	QCND0501	277,820	131,557	0.47	$11,900	1997	$11,900	0.93	$5,938	1.68	$10,144	$6,055	164 gal, 15 min res. Time, 50% wv, 2'6" dia., 5' long, 25 psig
D-P100-A502	T-505	1	0	Rectification Column Reflux Drum	QCND0502	4,906,301	2,323,304	0.47	$45,600	1997	$45,600	0.72	$26,621	1.68	$45,476	$27,147	6225 gal, 15 min res time, 50% wv, 7' dia, 22' long, 25 psig
D-P100-A502	T-512	1	0	Vent Scrubber	STRM0523	18,523	9,788	0.53	$99,000	1998	$99,000	0.78	$60,197	1.68	$102,043	$60,915	5' dia x 25' high, 4 stages, plastic Jaeger Tri-Packing
D-P100-A501	T-513	1	0	Kill Tank	STRM0518	149,897	149,897	1.00	$99,920	1999	$99,920	0.78	$99,920	1.68	$167,384	$99,920	18 psig, 30 min. res. time
D-P100-A601	T-630	1	0	Recycled Water Tank	STRM0602	179,446	84,120	0.47	$14,515	1998	$14,515	0.745	$8,254	1.68	$13,992	$8,353	7410 gal, 20 min. res., 2.5 psig, 9.5ft diam. x 14.25ft
D-P100-A701	T-703	1	0	Sulfuric Acid Storage Tank	STRM0710	1,647	1,912	1.16	$42,500	1997	$42,500	0.51	$45,860	1.76	$82,338	$46,767	20,000 gal, 240 hr supply, 90% wv, 12ft diam. x 24 ft, atmospheric
D-P100-A701	T-707	1	0	Antifoam Storage Tank	STRM0417	227	227	1.00	$14,400	1997	$14,400	0.71	$14,400	1.68	$24,600	$14,685	12,000 gal, 27 day supply, 10.5ft diam. X 18.5ft
D-P100-A701	T-720	1	0	CSL Storage Tank	STRM0735	2,039	859	0.42	$88,100	1997	$88,100	0.79	$44,495	1.68	$76,011	$45,375	30160 gal, 90% wv, 120 supply, 14.3ft diam. X 25 ft
D-P100-A802	T-804	1	0	Condensate Collection Tank	STRM811A	229,386	38,798	0.17	$7,100	1997	$7,100	0.71	$2,011	3.30	$6,766	$2,050	200 gal, 1.5 min. res. time
D-P100-A802	T-824	1	0	Condensate Surge Drum	STRM811A	150,000	38,798	0.26	$49,600	1997	$49,600	0.72	$18,734	5.00	$95,523	$19,105	2100 gal., 6' diam. X 10', 15 psig, res. time 11 min.
D-P100-A802	T-826	1	0	Deaerator	STRM0813	267,000	80,536	0.30	$165,000	1998	$165,000	0.72	$69,616	6.50	$457,896	$70,446	3030 gal., 15 psig, 10 min. res.
D-P100-A802	T-828	1	0	Blowdown Flash Drum	STRM0821	6,550	2,699	0.41	$9,200	1997	$9,200	0.72	$4,859	7.30	$36,168	$4,955	210 gal., 2.5' diam. X 6', 50 psig 17 min. res.
D-P100-A803	T-830	1	0	Hydrazine Drum	STRM813A	229,386	80,536	0.35	$12,400	1997	$12,400	0.93	$4,685	7.00	$33,440	$4,777	138 gal, 3.75' x 1.25' diam., 10 psig
D-P100-A901	T-904	1	0	Plant Air Receiver	STRM0101	159,950	53,316	0.33	$13,000	1997	$13,000	0.72	$5,894	1.68	$10,069	$6,011	300 gal., 200 psig
D-P100-A902	T-914	1	0	Process Water Tank	STRM0905	352,710	111,503	0.32	$195,500	1997	$195,500	0.51	$108,663	1.76	$195,095	$110,811	234360 gal, 8hr res. time
		29	**0**	**29**										**2.51**	**$ 4,099,742**	**$ 141,370**	
		sum	sum	total										avg.	sum	avg. (installed)	

TOTAL TAG ITEMS:	155
TOTAL PIECES:	310

Appendix 6

PHOENIX BIO-SYSTEMS, INC.

at ICM, Inc.:
310 North First Street, P.O. Box 397
Colwich, Kansas 67030
Phone: 316-796-0900 Fax: 316-796-0092
E-Mail: jbios@southwind.net

NREL Corn Stover to Ethanol – High Plains Fuel Ethanol Addition – Wastewater – Revision 1

Wastewater Analysis – 98,000 kg/hr total Flow

The attached mass balance estimate describes the proposed wastewater from corn stover processing at the High Plains Plant in York, NE. The overall wastewater, originally described by Merrick Engineering, has been further divided into components as they relate to biological digestion in an anaerobic wastewater treatment system. The stream given by Merrick is the sum of streams 520-Flash to WW Treatment, 247-IX to WW Treatment, 535- to WW Treatment and feedstock receiving pad run-off.

Fate of Components

There are several areas worthy of consideration in the analysis. The main organic components of this stream are ammonium acetate, acetic acid, ethanol, furfural and HMF. It has been assumed for the purposes of this analysis that these are all amenable to anaerobic digestion to some extent. The acetate and ethanol components are assumed to be 98 percent removable, while furfural and HMF are assumed to be 80 percent removable. The Corn Steep Liquor is assumed to be 92 percent removable as well.

Aerobic removals of residuals after anaerobic digestion are considered to be better, averaging 98%. Anaerobic digestion is chosen as the least cost method for removal of the largest components of organic COD.

All of the organic components have been expressed as their equivalent Chemical Oxygen Demand (COD) for complete conversion to carbon dioxide and water. Furthermore, values have been converted to pounds per day, which gives the average American reader a better "feel" for the amounts derived. It can be seen that the organic components alone generate approximately 72,000 pounds per day of COD for anaerobic digestion,

This amount of COD also generates some 437,000 cubic feet per day of biogas.

Sulfate

There is a very significant amount of sulfate included in this stream, due primarily to the need for sulfuric acid regeneration of IX resin used for the removal of Acetic Acid from the Hydrolysis-Fermentation stream. If all of the sulfate were to be converted to hydrogen sulfide in anaerobic digestion, then some 5,699 pounds per day of hydrogen sulfide would be produced. That is the equivalent of 138,000 ppm v/v in the biogas. However, in practice, anaerobic digesters fed very high sulfate streams appear to be self-limiting in hydrogen sulfide production. Hydrogen sulfide in biogas rarely exceeds 5,000 ppm v/v. For the purposes of this analysis, it was assumed that no more than 5,000 ppm v/v H2S would actually occur in the biogas. Therefore only a small

percentage of the available sulfate from ammonium sulfate was theoretically converted to H2S. The remainder is carried through the process as the salt of ammonia.

Ammonia Nitrogen

Ammonia is also very high in this waste stream, also due to the IX process regeneration. The hydrolysis of ammonium acetate in the digester results in over 9,300 pounds per day of Ammonia-Nitrogen which, when considered as COD, demands over 40,000 pounds per day of oxygen for conversion to nitrate. Anaerobic digestion will not remove this ammonia nitrogen but will pass it through the reactor in solution.

Among the options for treating this residual ammonia are air stripping and nitrification. Air stripping may be accomplished either during anaerobic digestion or afterward. It should be noted that 9,300 pounds per day of ammonia is likely to be a significant source of air emissions (4.6 tons per day of ammonia is equal to over 1,500 tons per year).

Nitrification is likely to be a more practical treatment, however, it will require some 40,000 pounds per day of oxygen for conversion to nitrate.

Secondary Treatment

Secondary aerobic treatment will be required in order to address both the residual ammonia and some 8,000 pounds per day of residual organics from the anaerobic digester.

Existing Capacity at High Plains – York

The existing waste water treatment plant at the High Plains Plant consists of a Bio-Methanation Anaerobic digester, a 2.6 million gallon aerobic lagoon with return activated sludge capability and 400 horsepower aeration, a sludge clarifier, and a sludge holding and aeration pond.

Wastewater is currently pre-treated in this system for discharge to the City of York. It is expected that the City of York might be capable of managing the hydraulic load from the corn stover process, but will impose stringent limits on COD, TSS, and Ammonia Nitrogen.

The existing anaerobic system at York is capable of 18,000 pounds per day of COD removal. Currently, the plant at York utilizes 50 to 75% of this capacity. Therefore, it will be necessary to add significant anaerobic pre-treatment for the corn stover process. Approximately 500,000 gallons of anaerobic digestion capacity will be required.

Although the existing aerobic system may be capable of treating a portion of the anaerobic effluent from the corn stover waste water, significant additional aerobic capacity will be required. The equivalent of at least 40,000 pounds per day of COD removal would be prudent. Furthermore, clarification and sludge management facilities would also require expansion.

Estimated Expansion Requirements

An equalization basin will be required with capacity no less than 300,000 gallons. An above-ground bolted tank with a cover, including foundations, pumps and controls is estimated to cost **$0.35 million**. The equalization basin is sized to accommodate approximately one half day flow. Flow would proceed from equalization to the anaerobic system.

Anaerobic digestion will require 500,000 gallons of additional capacity. Estimated cost of expansion is **$3.2 million**, including site work, foundations, reactors and ancillary equipment.

Expansion of aerobic facilities can be accomplished with the addition of four 350,000 gallon Sequencing Batch Reactors, with a capacity of 48,000 pounds per day of oxygen transfer, along with de-nitrification capability. Aeration and mixing would require approximately 1,400 horsepower. Estimated cost for the aerobic section of the expanded plant is **$4.3 million.**

Expansion of clarification facilities would not be required as Sequencing Batch Reactors also act as clarifiers during the "Settling Phase".

The City of York is unlikely to accommodate wastewater with nitrate concentrations approximating 2,870 mg/l, therefore, de-nitrification capability would be required. Residual ammonia totals over 9,570 ppd or 835 mg/l, and when converted to nitrate, will be over 2,870 mg/l (32,920 ppd). Conventional means of de-nitrification, such as single or double sludge de-nitrification are likely not adequate for this task, however, Sequencing Batch Reactors have inherent de-nitrification capability. Inclusion of an "anoxic" phase in the Batch sequence converts nitrate to nitrogen gas.

Final filtration through pressure sand filters is recommended. Pressure Sand Filters with 200 square feet of filtration surface area would suffice. This system would consist of 4 x 8'd pressure sand filters, stainless steel construction, with auto-backwash, in a small building. The estimated cost for this system is **$0.28 million.**

Summarizing capital costs;

- Equalization, one 300,000 gal eq. Tank- **$ 0.35 M**
- Anaerobic System, as above- **$3.2 M**
- Aerobic SBR's – 4 x 350,000 gal - **$4.3 M**
- Filters- 200 sq. ft. - **$0.28 M**
-

Total cost of capital improvements without NPDES discharge is estimated to be **$8.13 million.**

The current PFD for the corn stover operation calls for the recycling of wastewater to process use. This is feasible provided that there is sufficient water removed from the process to provide adequate desalting of the total process water. Final sand filtration is recommended for this case. There will be approximately 4,400 mg/l of inorganic salts in the recycle water. This concentration, approaching 0.5% brine could be problematic for re-use. With 50% dilution from fresh water the risk of salting the process is reduced considerably.

In the event that the wastewater cannot be re-used, the city of York may not accommodate the hydraulic flow (622,000 gpd) created by the corn stover process. Current hydraulic flow from existing facility averages over 350,000 gpd, including cooling tower blow-down. An NPDES permit may be required for direct discharge of the additional wastewater.

With NPDES discharge of wastewater capital cost is likely to rise for the cost of out-fall, monitoring stations and additional engineering/legal expenses. Operating costs would also increase due to increased monitoring.

ADDENDUM (10-19-99)

Reduced Hydraulic Flow

Closer review of the various streams comprising the wastewater stream for this project indicates that there will be significantly less wastewater volume than originally believed. Current mass

balance for the processing facility indicates an average flow of 98,267 kg/hr versus the original flow of 217,300 kg/hr. The difference is apparently due to an overestimate of run-off from the feedstock delivery pad during storm events. Correction of this estimate and leveling of storm water flow to the wastewater treatment system results in a much lower total flow.

Unfortunately, the reduced hydraulic load has little impact on the size requirements of both the anaerobic and aerobic treatment units. The reason for this is that all of the organic and nitrogenous wastes are carried by the other plant streams.

The equalization basin and the aerobic SBR system can be reduced in size in accord with the lower hydraulic flow. The information given above is valid for the reduced flow case.

Removal of IX Treatment

It has been suggested that the Ion Exchange removal of Acetic acid might be eliminated from the proposed process. If research shows this to be possible, the savings in wastewater treatment and chemical costs would be significant.

Although Acetic Acid would still be produced in Stover hydrolysis, if it could be successfully carried through fermentation, it would be removed in the anaerobic reactor. This water could be recycled without the risk of acetate poisoning of the yeast fermentation.

Furthermore, the deletion of IX would eliminate the requirement for the purchase and application of Ammonia for regeneration. This would also remove the requirement for over 40,000 ppd of oxygenation for nitrogen removal in the aerobic wastewater treatment system.

Mass Balance and operating cost estimates have been completed for both of these cases;
1- Reduced hydraulic flow to 98,000 kg/hr and
2- Elimination of IX treatment for acetic acid removal.

It is obvious that the elimination of IX treatment has very significant economic impact on operating costs for wastewater treatment. The net operating cost of treatment for the reduced flow case (including credit for biogas produced) is **$913,000** per year without depreciation. The net operating cost for treatment without IX is **$122,000** per year. Net savings is $791,000 per year or 87% of operating costs. The difference is due to reduced operating costs associated with the removal of Ammonia-derived nitrogen from the wastewater.

In addition, capital costs will be lower due to the need for much less aerobic capacity. The aerobic section of wastewater treatment can be reduced from 4 x 350,000 gal SBR's to 2 x 180,000 gal SBR's. Aeration systems will be reduced as well. Capital cost for the reduced aerobic SBR system is estimated at **$1.73 M.** Capital for all components of this system would be;

- Equalization, one 200,000 gal eq. Tank- **$ 0.295 M**
- Anaerobic System, as above- **$3.2 M**
- Aerobic SBR's - **$1.23 M**
- Filters- 150 sq. ft. - **$0.245 M**

The total capital for this complete system would be **$4.97 M,** which is a capital savings of 39%.

Some Caustic has been included in the operating costs for this case since ammonia nitrogen is no longer in high concentration. In the earlier case no caustic was required due to the presence of large amounts of ammonia.

In addition, sulfate is no longer a problem as the elimination of IX and associated sulfuric acid has reduced available sulfate to what would be derived from feedstock and make-up fresh water. It is expected that Hydrogen sulfide would not exceed 500 ppm in the biogas, which is easily removed with low cost scrubbing.

Salt concentration in this treated wastewater would be quite low and would pose no significant risk for re-use.

This system would be capable of ;
a- Producing water for discharge to the environment
b- Producing water for discharge to the City of York without surcharge
c- Producing water for re-use in the process

Cooling Tower Blow-Down
Cooling tower blow-downs have been deleted from this analysis since these waters do not contain appreciable amounts of pollutants. Generally, cooling tower blow-downs can be released to the environment on NPDES permits, without difficulty.

Operating Costs - NREL - Corn Stover Wastewater Model - 98,000 kg/hr to WW - WITHOUT IX

	ANAEROBIC BIO-METHANATOR		DISCHARGE WITH SBR AEROBIC TREATMENT	
PARAMETERS	AMOUNTS	DAILY COST	AMOUNTS	DAILY COST
Flow, Gallons Per Minute (GPM)	301.00		301.00	
Flow, Gallons Per Day (GPD)	433,440.00		433,440.00	
Chemical Oxygen Demand (COD) mg/l	20,000.00		1,800.00	
Biological Oxygen Demand (BOD5) mg/l	12,000.00		1,080.00	
Pounds Per Day COD	72,271.82		6,504.46	
Pounds Per Day BOD	50,590.28		4,553.12	
Inlet Temperature	30C		30C	
Total Nitrogen mg/l	250.00		205.00	
Total Nitrogen PPD	903.40		740.79	
Total Phosphate mg/l	30.00		28.00	
Total PhosphatePPD	108.41		101.18	
COD Space Loading Rate g/l/d	18.00		2.00	
COD Reduction	0.93		0.98	
Residual COD mg/l	1,400.00		36.00	
Residual COD PPD	5,059.03		130.09	
Residual BOD5 mg/l	840.00		10.80	
Residual BOD5 PPD	3,035.42		91.06	
TSS mg/l	0.00		100.00	
TSS PPD	0.00		361.36	
Horsepower Required:				
Blower Horsepower	5.00		150.57	
Mixing	0.00		67.75	
Pumping	34.68		43.34	
Total Horsepower	39.68		261.67	
Cost per kwh	0.035		0.035	
Kwh per day	704.63	$24.66	4,647.17	$162.65
Chemicals Required, lbs/day:				
Nitrogen	(773.31)	$0.00	0.00	$0.00
Phosphate	(65.04)	$0.00	0.00	$0.00
Micro-Nutrients	7.23	$3.61	0.00	$0.00
Caustic lbs/day Required	328.11	$49.22	0.00	$0.00
Polymer @ $ 2.50/lb	0.00	$0.00	35.00	$87.50
Chlorine	0.00	$0.00	0.00	$0.00
Sludge (Biomass) Generation:				
Dry Weight Yield, lbs/day	1,445.44		1,951.34	
Wet Weight of Sludge, lbs/day	24,090.61		195,133.92	
Sludge Total Solids	6%		1%	
Sludge Yield on COD	2%		30%	

Operating Costs - NREL - Corn Stover Wastewater Model - 98,000 kg/hr to WW - WITHOUT IX

PARAMETERS	AMOUNTS	DAILY COST	AMOUNTS	DAILY COST
Sludge Disposal :				
Dewatering @ $ 0.XX per 1000 lb wet weight	0.00	$0.00	0.00	$0.00
Volume Reduction	0%		0.00	$0.00
Disposal Volume-gal	0.00		23,369.33	
Disposal @ $ 0.0X/gal	0.00	$0.00	0.010	$233.69
Bio-Gas Produced (CFD):	443,987.25		0.00	
Methane Yield (85%) CFD	377,389.16		0.00	
Less Heating Requirement	0.00		0.00	
Net Methane for energy- CFD	377,389.16		0.00	
Bio-Gas Credit ($2.50/MMBTU Methane)		($943.47)	0.00	$0.00
Labor:				
Cost per hour ($)	18.00		18.00	
Manhours / Day	3.00	$54.00	8.00	$144.00
Maintenance parts	50.00	$60.00	50.00	$60.00
Sewer Surcharge (if applicable):				
Flow @ $0.XX /1000 gal	0.00	$0.00	1.00	$433.44
Allowable BOD5 Concentration mg/l	300.00		300.00	
PPD Allowable BOD5	1,084.08		1,084.08	
Residual BOD5 to Sewer PPD	1,951.34		(993.01)	
BOD5 Surcharge @ $x.xx/lb	0.20	$0.00	0.20	$0.00
Allowable TSS Concentration mg/l	250.00		250.00	
PPD Allowable TSS	903.40		903.40	
Residual TSS to Sewer PPD	0.00		361.36	
TSS @ $0.XX /lb	0.00	$0.00	0.00	$0.00
Total Daily Cost		**($751.98)**		**$1,121.28**
Annual Cost (Days per year)	330.00	**($248,153.43)**	330.00	**$370,023.84**
Daily Operating Cost w/o Methane Credit		**$191.49**		**$1,121.28**
Annual Operating Cost w/o Methane Credit	330.00	**$63,192.63**	330.00	**$433,216.47**

Operating Costs - NREL - Corn Stover Wastewater Model - 98,000 kg/hr to WW

PARAMETERS	ANAEROBIC BIO-METHANATOR AMOUNTS	ANAEROBIC BIO-METHANATOR DAILY COST	DISCHARGE WITH SBR AEROBIC TREATMENT AMOUNTS	DISCHARGE WITH SBR AEROBIC TREATMENT DAILY COST
Flow, Gallons Per Minute (GPM)	432.00		432.00	
Flow, Gallons Per Day (GPD)	622,080.00		622,080.00	
Chemical Oxygen Demand (COD) mg/l	13,700.00		9,450.00	
Biological Oxygen Demand (BOD5) mg/l	8,220.00		5,670.00	
Pounds Per Day COD	71,052.09		49,010.38	
Pounds Per Day BOD	49,736.46		34,307.27	
Inlet Temperature	30C		30C	
Total Nitrogen mg/l	2,959.00		2,920.00	
Total Nitrogen PPD	15,346.21		15,143.95	
Total Phosphate mg/l	30.00		28.00	
Total PhosphatePPD	155.59		145.22	
COD Space Loading Rate g/l/d	18.00		4.00	
COD Reduction	0.93		0.98	
Residual COD mg/l	959.00		189.00	
Residual COD PPD	4,973.65		980.21	
Residual BOD5 mg/l	575.40		56.70	
Residual BOD5 PPD	2,984.19		686.15	
TSS mg/l	0.00		100.00	
TSS PPD	0.00		518.63	
Horsepower Required:				
Blower Horsepower	5.00		1,134.50	
Mixing	0.00		204.21	
Pumping	49.77		62.21	
Total Horsepower	54.77		1,400.92	
Cost per kwh	0.035		0.035	
Kwh per day	972.65	$34.04	24,880.29	$870.81
Chemicals Required, lbs/day:				
Nitrogen	(15,218.32)	$0.00	0.00	$0.00
Phosphate	(112.96)	$0.00	0.00	$0.00
Micro-Nutrients	7.11	$3.55	0.00	$0.00
Caustic lbs/day Required	0.00	$0.00	0.00	$0.00
Polymer @ $ 2.50/lb	0.00	$0.00	35.00	$87.50
Chlorine	0.00	$0.00	0.00	$0.00
Sludge (Biomass) Generation:				
Dry Weight Yield, lbs/day	1,421.04		14,703.11	
Wet Weight of Sludge, lbs/day	23,684.03		1,470,311.43	
Sludge Total Solids	6%		1%	
Sludge Yield on COD	2%		30%	

Operating Costs - NREL - Corn Stover Wastewater Model - 98,000 kg/hr to WW

PARAMETERS	AMOUNTS	DAILY COST	AMOUNTS	DAILY COST
Sludge Disposal :				
Dewatering @ $ 0.XX per 1000 lb wet weight	0.00	$0.00	0.00	$0.00
Volume Reduction	0%		0.00	$0.00
Disposal Volume-gal	0.00		176,085.20	
Disposal @ $ 0.0X/gal	0.00	$0.00	0.010	$1,760.85
Bio-Gas Produced (CFD):	436,494.04		0.00	
Methane Yield (85%) CFD	371,019.94		0.00	
Less Heating Requirement	0.00		0.00	
Net Methane for energy- CFD	371,019.94		0.00	
Bio-Gas Credit ($2.50/MMBTU Methane)		($927.55)	0.00	$0.00
Labor:				
Cost per hour ($)	18.00		18.00	
Manhours / Day	3.00	$54.00	8.00	$144.00
Maintenance parts	50.00	$60.00	50.00	$60.00
Sewer Surcharge (if applicable):				
Flow @ $0.XX /1000 gal	0.00	$0.00	1.00	$622.08
Allowable BOD5 Concentration mg/l	300.00		300.00	
PPD Allowable BOD5	1,555.89		1,555.89	
Residual BOD5 to Sewer PPD	1,428.30		(869.74)	
BOD5 Surcharge @ $x.xx/lb	0.20	$0.00	0.20	$0.00
Allowable TSS Concentration mg/l	250.00		250.00	
PPD Allowable TSS	1,296.57		1,296.57	
Residual TSS to Sewer PPD	0.00		518.63	
TSS @ $0.XX /lb	0.00	$0.00	0.00	$0.00
Total Daily Cost		**($775.95)**		**$3,545.24**
Annual Cost (Days per year)	330.00	**($256,064.97)**	330.00	**$1,169,929.96**
Daily Operating Cost w/o Methane Credit		**$151.60**		**$3,545.24**
Annual Operating Cost w/o Methane Credit	330.00	**$50,026.48**	330.00	**$1,219,956.45**

NREL Wastewater- Corn Stover Case - Mass Balance Estimate - 98,000 kg/hr Flow - WITHOUT IX

Wastewater Components	Total Wastewater - Kg/hr	Total Wastewater - Lbs/day	Conc - mg/l	Conc as COD - mg/l	COD - Lbs/day	COD for Anaerobic Digestion - Lbs/day	Residual COD - Lbs/day	Other Residuals - Lbs/day	Residuals Conc - as COD - mg/l	After Aerobic & Deni mg/l
Total Flow-	68,635.0	3,623,928.0				3,623,928.0	3,623,928.0			3,623,928.0
Gallons		434,523.7				434,523.7	434,523.7			434,523.7
Insoluble solids (is)	0.0	0.0								
Soluble solids (ss)	1,297.1	68,486.9	18,905.3							
Water	67,337.9	3,555,441.1								
Ethanol	22.0	1,161.6	320.7	352.7	1,277.8	1,277.8	25.6		7.1	0.1
CSL (ss)	33.0	1,742.4	481.0	529.1	1,916.6	1,916.6	153.3		42.3	0.8
(NH4)2SO4 for digestion	0.0	0.0								
SO4 for conversion from Amm sulfate**	0.0	0.0	0.0						0.0	
NH4 from Amm Sulfate		0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Unconverted (NH4)2SO4	0.0	0.0	0.0					0.0		0.0
NH4 from Amm Acetate	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0
Total Acetate C2H4O2	693.1	36,595.7	10,102.0	11,112.2	40,255.2	40,255.2	805.1		222.2	4.4
Furfural	457.0	24,129.6	6,660.8	8,659.0	26,542.6	26,542.6	5,308.5		1,465.4	44.0
HMF	31.0	1,636.8	451.8	587.4	1,800.5	1,800.5	360.1		99.4	3.0
NH4	4.0	211.2	58.3	250.7	908.2		908.2		250.7	7.5
NH4OH***	54.0	2,851.2	787.1					333.0	64.0	1.9
Other	3.0	158.4	43.7	48.1	174.2	174.2	17.4		4.8	2.4
TOTALS			18,905.3	21,539.2	**72,875.1**	**71,966.8**	**7,578.2**	333.0	2,155.9	64.2
Hydogen Sulfide - *								0.0		
BioGas Production- CFD- 85% CH4						442,113.6				
Energy mmbtu/day						375.8				

* H2S at 5,000 v/v ppm in biogas

** SO4 estimated limit of conversion at 5,000 ppm H2S- in biogas

*** Expected to be neutral salts in digester

NREL Wastewater- Corn Stover Case - Mass Balance Estimate - 98,000 kg/hr Flow

Wastewater Components	Total Wastewater - Kg/hr	Total Wastewater - Lbs/day	Conc - mg/l	Conc as COD - mg/l	COD - Lbs/day	COD for Anaerobic Digestion - Lbs/day	Residual COD - Lbs/day	Other Residuals - Lbs/day	Residuals Conc - as COD - mg/l	After Aerobic & Deni mg/l
Total Flow-	98,267.0	5,188,497.6				5,188,497.6	5,188,497.6			5,188,497.6
Gallons		622,122.0				622,122.0	622,122.0			622,122.0
Insoluble solids (is)	0.0	0.0								
Soluble solids (ss)	1,907.0	100,689.6	19,413.3							
Water	96,360.0	5,087,808.0								
Ethanol	22.0	1,161.6	224.0	246.4	1,277.8	1,277.8	25.6		4.9	0.0
CSL (ss)	33.0	1,742.4	335.9	369.5	1,916.6	1,916.6	153.3		29.6	0.6
(NH4)2SO4 for digestion	16.0	844.8								
SO4 for conversion from Amm sulfate**	11.5	607.2	117.1						0.0	
NH4 from Amm Sulfate	4.5	237.6	45.8	197.0	1,021.7		1,021.7	237.6	197.0	5.9
Unconverted (NH4)2SO4	401.0	21,172.8	4,082.2					21,172.8		4,082.2
NH4 from Amm Acetate	176.9	9,340.3	1,800.8	7,743.6	40,163.4		40,163.4	9,340.3	7,743.6	232.3
Total Acetate C2H4O2	693.1	36,595.7	7,055.8	7,761.3	40,255.2	40,255.2	805.1		155.2	3.1
Furfural	457.0	24,129.6	4,652.3	6,047.9	26,542.6	26,542.6	5,308.5		1,023.5	30.7
HMF	31.0	1,636.8	315.6	410.3	1,800.5	1,800.5	360.1		69.4	2.1
NH4	4.0	211.2	40.7	175.1	908.2		908.2		175.1	15.8
NH4OH***	54.0	2,851.2	549.7					549.7	0.0	106.0
Other	3.0	158.4	30.5	33.6	174.2	174.2	17.4		3.4	1.7
TOTALS			19,250.4	22,984.7	**114,060.1**	**71,966.8**	**48,763.2**	31,300.4	9,401.7	4,480.4
Hydogen Sulfide - *								215.3		
BioGas Production- CFD- 85% CH4						442,113.6				
Energy mmbtu/day						375.8				

* H2S at 5,000 v/v ppm in biogas

** SO4 estimated limit of conversion at 5,000 ppm H2S- in biogas

*** Expected to be neutral salts in digester

Appendix 7

Structure of Appendix 7

Proforma

Sensitivity Analysis

Cellulase Source Study

Comparison of On-site cellulase production methods

Comparison of On-site and Purchased Cellulase

Method A: "BASED ON PUREVISION LABORATORY RESULTS OF COMPARISON"

Method B: "BASED ON PRODUCT SPECIFICATIONS PROVIDED BY SPECIALTY ENZYMES INC."

Proforma

High Plains Corp.
York, NE Co-located
Stover-to-Ethanol Plant

A
1/26/00

EL ENZYMATIC HYDROLYSIS - PRO FORMA
erlying Assumptions & Input Variables

CURRENT SITUATION:

The Pro Forma models an Enzymatic Hydrolysis Ethanol plant using corn stover as the feed stock.

ETHANOL

The plant will convert corn stover to fuel grade ethanol utilizing enzymatic hydrolosis.
Corn stover feed rate of 71,977 kg/hr (str 101), produce estimated total output in
equivalent kilograms of fuel grade ETOH 9,151 kg/hr. = 76,871,691 kg / year (str 515)
gal./short ton= 74.1 3,065 gal/hr = 25,746,124 gal / year
gal./metric ton= 81.7

Increase to current York yearly production: 70%
The model assumes renewal of the ethanol excise tax credit of $.54 per gallon to the blender
and **NOT** the small producer tax credit of $.10 per gallon through the year 2015 for a total ethanol value of
$1.10 per gallon or $0.37 per kg and **$ 28,320,736 per year TOTAL Ethanol sales**

CARBON DIOXIDE

Currently, carbon dioxide from the High Plains York fermentations is sold to a CO_2 compression company.
Diverting the CO_2 (stm 550) from the stover plant into this stream for sale as opposed to the atmosphere provides
110,749 kg/hr = 930,294 ton / year with a value of $ 4.13 per metric ton
WITH THIS PROFORMA NO CO_2 IS SOLD. **CO_2 Value/year = $0**

LIGNIN

A Lignin co-product is produced and sold as combustion fuel material. A total amount of lignin in the stream (stm 601B) is
63,778 kg/hr = 535,734 metric ton / year is produced from the process.
The water in the lignin stream must be vaporized at a net BTU cost for the stream (stm 601B). Water vaporized is
43,969 kg/hr = 369,337 metric ton/year is vaporized at 1,100 BTU/lb loss = (107) MM BTU/hr
The remaining 19,809 kg/hr of stream 601B has 24,251 BTU/kg value = 480 MM BTU/hr
Total heating value from stream 601A is 374 MM BTU/hr
Gross Lignin Value/year = $7,848,926
Transport Cost = $7,848,926
Net Lignin Value = $0

METHANE

The digester produces 85% methane @ 353 kg/hr (stm 615) 44,332 BTU/kg CH4
Total heating value from Methane is 16 MM BTU/hr
methane is used in the DDG dryers and based on BTU value of $2.50 MM BTU
METHANE Value/year = $328,822

DIGESTER SLUDGE

The digester produces (stm 623) 0 kg/hr of sludge as fuel = 2,254 BTU/lb
based on 9,845 btu/lb biomass and 70% water in the sludge. = 4,969 BTU/kg
Total heating value from sludge is 0.00 MM BTU/hr
SLUDGE Value/year = $0

Sale of methane and lignin, based on BTU value is **$328,822 per year**

Total projected facility sales would be $28,649,558 per year

High Plains Corp.
York, NE Co-located
Stover-to-Ethanol Plant

CAPITAL INVESTMENT ASSUMPTIONS

1) Total capital investment

Civil Structural			1,500,000	
Area 100			6,146,434	
Area 200			14,955,166	
Area 300			4,028,307	
Area 307			3,714,334	
Area 400			8,676,000	
Area 500			7,515,486	
Area 600			9,824,251	
Area 700			273,557	
Area 800			3,684,612	
Area 900			2,236,491	
Fixed Capital			$62,554,640	
INDIRECTS	Prorateable	3.5%	$2,189,412	
	Process Development	2.0%	$1,251,093	
	Field Expense	8.0%	$5,004,371	
	Home Office Constr. Fee	12.0%	$7,506,557	
	Contingency	10.0%	$6,255,464	
	Start-up, Permits, Fees	3.0%	$1,876,639	
Working Capital per estimate			$1,590,867	1 mos Raw matls. + O&M
	Total Plant Cost		$88,229,044	
FEDERAL & STATE GRANTS		10%	($8,822,904)	
	Net Capital Investment		**$79,406,139**	

OPERATING COST ASSUMPTIONS

8,400 hr/yr

Utilities (Rates based on 25,746,124 gal/yr produced)

	Amount/hr	*Units*	*$/unit*	*Cost /hr.*	**Total Cost /yr**
*Electricity	12,893	Kw-hr	$0.035	$451	$3,790,636
Well water	79,972	kg	$0.000	$0	$0
*Wastewater	39,119	kg	$0.00026	$10	$86,808
*Gypsum waste disposal	1,137	kg	$0.0364	$41	$347,327
		mTon	$1.103	$0	$0
Total Utilities				$503	$4,224,771

**** Quoted by High Plains***

High Plains Corp.
York, NE Co-located
Stover-to-Ethanol Plant

Raw Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Corn Stover DRY (stm 101 less water)	37,500	kg	$0.016	$597.41	$5,018,284
*Sulfuric Acid (stm 710)	860	kg	$0.100	$86.26	$724,592
*Calcium Hydroxide (Lime stm 227)	337	kg	$0.293	$98.70	$829,039
*Ammonia (stm 717)	445	kg	$0.162	$72.07	$605,374
Corn Steep Liquor (stm 735)	859	kg	$0.051	$43.80	$367,909
Nutrients (stm 415)	60	kg	$0.291	$17.48	$146,846
Purchased Cellulase	0	kg	$3.000	$0.00	$0
*Natural Gasoline (stm 701)	391	kg	$0.155	$60.36	$506,988
*Rolling Stock Gasoline	79	kg	$0.155	$12.32	$103,470
*WWT Chemicals	5	kg	$2.237	$11.98	$100,603
*CW Chemicals	17	kg	$1.428	$24.38	$204,791
*BFW Chemicals	73.8	kg	$0.226	$16.65	$139,833
*Boiler Fuel (stm 813)	190	Mbtu	$2.500	$476.07	$3,998,989
Total Raw Materials				$1,517	$12,746,718

Quoted by High Plains

Processing Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
*Antifoam (Corn Oil)	79	kg	$0.304	$24	$200,961
Total Processing Materials				$24	$200,961

Quoted by High Plains

Operations and Maintenance Costs - DRY HANDLING (area 100)	each/day		wage	hr/day each	Total Cost /yr.
*Supervisors	0.5	$	20.00	12	$43,800
*Operators	2.0	$	16.00	12	$140,160
*Laborers	8.0	$	16.00	12	$560,640
*Maintenance	2.0	$	16.00	12	$140,160
Operations and Maintenance Costs - HYDROLYSIS/FERMENTATION (area 200, 300, 400, 500, 600)					
*Supervisors	1.0	$	20.00	12	$87,600
*Operators	9.0	$	16.00	8	$420,480
*Laborers	4.0	$	16.00	8	$186,880
*Technicians (Includes Lab.)	3.0	$	16.00	8	$140,160
*Maintenance	3.0	$	16.00	8	$140,160
Operations and Maintenance Costs - Utilities (area 700, 800, 900)					
*Supervisors	0.5	$	20.00	12	$21,900
*Operators	3.0	$	16.00	8	$70,080
*Laborers	1.0	$	16.00	8	$23,360
*Technicians	1.0	$	16.00	8	$23,360
*Maintenance	2.0	$	16.00	8	$46,720

Quoted by High Plains Standard HPY shifts are 12 hours.

Total Operations and maintenance labor costs $2,045,460

High Plains Corp.
York, NE Co-located
Stover-to-Ethanol Plant

Other Operations and Maintenance Costs			
Payroll Overhead	35% of operating labor	$	715,911
Maintenance Costs	2% of plant cost	$	1,251,093
Operating Supplies	0.25% of plant cost	$	156,387
Environmental	0.50% of plant cost	$	312,773
Local Taxes	1% of plant cost	$	625,546
Insurance	0.50% of plant cost	$	312,773
Overhead Costs	40% of labor, supervision,maint cost	$	818,184
Administrative Costs	1% of annual sales (less tax credits)	$	105,559
Distribution and Sales	0.5% of annual sales (less tax credits)	$	-
Total O&M Costs			$6,343,686

OTHER MODEL ASSUMPTIONS

Average prevailing market price of fuel grade ETOH:		$0.37	per kg
Assumes renewal of the ethanol excise tax credit of $.54 per gallon and the small producer tax credit of $.10 per gallon through the year 2007	$	1.10	per gallon
*Value of CO_2 produced	$	4.13	per metric ton
*Price for Electricity		$0.035	per KWhr
*Gas price per million BTU		$2.500	per MM BTU

			68% Dry matter	
Corn Stover feedstock cost- **dry basis/short ton**	$	14.45	$0.016	per kg
			$15.93	per metric ton

Plant on-stream factor	0.959
Plant operating hours per year	8400
Depreciable Life of Capital Equipment	15 years
Average annual commodity escalation rate:	3.0%
Average annual cost escalation rate:	3.0%

Quoted by High Plains

1. There are no land acquisiton costs included.
2. There are no off site costs included (e.g. public road improvements, extensions of power, water, telephone services)
3. There is a source of qualified construction personnel within daily driving distance of the site
4. There exist adequate roads and rail roads to allow equipment delivery.
5. The costs for air and water permits are not included.
6. Soils are adequate for conventional foundation designs.

EL ENZYMATIC HYDROLYSIS - PRO FORMA

E 1: Produce Fuel Grade Ethanol A 1/26/00

itial Investment:	month1	month2	month3	month4	month5	month6	month7	month8	month9	month10	month11	month12	month13	month14	month15	month16	month17	month18	TOTAL
otal Fixed Capital Cost	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$4,000,000	$11,406,139	$79,406,139
onstruction Financing & Fees @10%		33,333	66,667	100,000	133,333	166,667	200,000	233,333	266,667	300,000	333,333	366,667	400,000	433,333	466,667	500,000	533,333	266,667	4,800,000
oan Origination Fee @ 2.0%	1,588,123																		1,588,123
egal Fees	40,000																	0	40,000
uilder's All Risk/General Liability	50,000																	0	50,000
orking Capital (Financed)																		0	0
Total Capital Investment Required	$5,678,123	$4,033,333	$4,066,667	$4,100,000	$4,133,333	$4,166,667	$4,200,000	$4,233,333	$4,266,667	$4,300,000	$4,333,333	$4,366,667	$4,400,000	$4,433,333	$4,466,667	$4,500,000	$4,533,333	$11,672,806	$85,884,262

rating Projection:	Year 1: 1999 / 2000	Year 2: 2000/2001	Year 3: 2001/2002	Year 4: 2002/2003	Year 5: 2003/2004	Year 6: 2004/2005	Year 7: 2005/2006	Year 8: 2006/2007	Year 9: 2007/2008	Year 10: 2008/2009	Year 11: 2006 / 2007	Year 12: 2007 / 2008	Year 13: 2008 / 2009	Year 14: 2009 / 2009	Year 15: 2010 / 2011	Year 16: 2011 / 2012	Year 17: 2012 / 2013	Year 18: 2013 / 2014	Year 19: 2014 / 2015	Year 20: 2015 / 2016
al of fuel grade ethanol produced	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124	25,746,124
ontract sale price per gallon	$1.100	$1.133	$1.167	$1.202	$1.238	$1.275	$1.313	$1.353	$1.393	$1.435	$1.478	$1.523	$1.568	$1.615	$1.664	$1.714	$1.765	$1.818	$1.873	$1.929
Gross Annual Revenue	$28,320,736	$29,170,358	$30,045,469	$30,946,833	$31,875,238	$32,831,495	$33,816,440	$34,830,933	$35,875,861	$36,952,137	$38,060,701	$39,202,522	$40,378,598	$41,589,956	$42,837,655	$44,122,784	$45,446,468	$46,809,862	$48,214,158	$49,660,582
mall Ethanol Producer Tax Credit @ $0.0000 per gallon	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total projected ethanol sales and credit	$28,320,736	$29,170,358	$30,045,469	$30,946,833	$31,875,238	$32,831,495	$33,816,440	$34,830,933	$35,875,861	$36,952,137	$38,060,701	$39,202,522	$40,378,598	$41,589,956	$42,837,655	$44,122,784	$45,446,468	$46,809,862	$48,214,158	$49,660,582
alue of electricity	$0.035	$0.036	$0.037	$0.038	$0.039	$0.041	$0.042	$0.043	$0.044	$0.046	$0.047	$0.048	$0.050	$0.051	$0.053	$0.055	$0.056	$0.058	$0.060	$0.061
Gross Annual Co-Product Revenue	$328,822	$338,687	$348,847	$359,313	$370,092	$381,195	$392,631	$404,410	$416,542	$429,038	$441,909	$455,167	$468,822	$482,886	$497,373	$512,294	$527,663	$543,493	$559,797	$576,591
Gross Sales and Credit	$28,649,558	$29,509,045	$30,394,316	$31,306,146	$32,245,330	$33,212,690	$34,209,071	$35,235,343	$36,292,403	$37,381,175	$38,502,611	$39,657,689	$40,847,420	$42,072,842	$43,335,027	$44,635,078	$45,974,131	$47,353,354	$48,773,955	$50,237,174
perating Expenses:																				
Utilities	4,224,771	4,351,514	4,482,059	4,616,521	4,755,017	4,897,667	5,044,597	5,195,935	5,351,813	5,512,368	5,677,739	5,848,071	6,023,513	6,204,218	6,390,345	6,582,055	6,779,517	6,982,902	7,192,389	7,408,161
Raw Materials	12,746,716	13,129,120	13,522,993	13,928,683	14,346,544	14,776,940	15,220,248	15,676,856	16,147,161	16,631,576	17,130,524	17,644,439	18,173,772	18,718,986	19,280,555	19,858,972	20,454,741	21,068,383	21,700,435	22,351,448
Processing Materials	200,961	206,990	213,200	219,596	226,184	232,969	239,958	247,157	254,572	262,209	270,075	278,177	286,523	295,119	303,972	313,091	322,484	332,158	342,123	352,387
Operation & Maintenance	6,343,686	6,533,997	6,730,017	6,931,917	7,139,875	7,354,071	7,574,693	7,801,934	8,035,992	8,277,072	8,525,384	8,781,145	9,044,580	9,315,917	9,595,395	9,883,257	10,179,754	10,485,147	10,799,701	11,123,692
Property Tax @ 0.50% Book Value	429,421	402,953	376,484	350,015	323,546	297,078	270,609	244,140	217,672	191,203	164,734	138,265	111,797	85,328	58,859	58,859	58,859	58,859	58,859	58,859
Depreciation	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	5,293,743	0	0	0	0	0
Total Operating Expense	$29,239,301	$29,918,316	$30,618,496	$31,340,475	$32,084,908	$32,852,468	$33,643,849	$34,459,765	$35,300,953	$36,168,170	$37,062,198	$37,983,841	$38,933,927	$39,913,310	$40,922,869	$36,696,234	$37,795,355	$38,927,450	$40,093,508	$41,294,547
Net Operating Income	($589,742)	($409,271)	($224,180)	($34,330)	$160,422	$360,222	$565,222	$775,578	$991,450	$1,213,005	$1,440,412	$1,673,848	$1,913,492	$2,159,532	$2,412,159	$7,938,844	$8,178,775	$8,425,904	$8,680,447	$8,942,626
Net Operating Cash Flow	$4,704,000	$4,884,471	$5,069,563	$5,259,413	$5,454,165	$5,653,965	$5,858,965	$6,069,321	$6,285,193	$6,506,748	$6,734,155	$6,967,590	$7,207,235	$7,453,274	$7,705,901	$7,938,844	$8,178,775	$8,425,904	$8,680,447	$8,942,626

E 1: Hypothetical Financing Scenarios:

E 1A: 100% Debt Financing

mortization 15 yrs	Year 1:	Year 2:	Year 3:	Year 4:	Year 5:	Year 6:	Year 7:	Year 8:	Year 9:	Year 10:	Year 11:	Year 12:	Year 13:	Year 14:	Year 15:	Year 16:	Year 17:	Year 18:	Year 19:	Year 20:
terest Rate 7.00%	1999 / 2000	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009	2006 / 2007	2007 / 2008	2008 / 2009	2009 / 2009	2010 / 2011	2011 / 2012	2012 / 2013	2013 / 2014	2014 / 2015	2015 / 2016
et Operating Cash Flow *(from above)*	4,704,000	4,884,471	5,069,563	5,259,413	5,454,165	5,653,965	5,858,965	6,069,321	6,285,193	6,506,748	6,734,155	6,967,590	7,207,235	7,453,274	7,705,901	7,938,844	8,178,775	8,425,904	8,680,447	8,942,626
Debt Interest	6,011,898	5,772,657	5,516,669	5,242,762	4,949,681	4,636,084	4,300,536	3,941,500	3,557,330	3,146,269	2,706,434	2,235,810	1,732,243	1,193,426	616,892	0	0	0	0	0
Debt Principal	3,417,732	3,656,973	3,912,961	4,186,869	4,479,949	4,793,546	5,129,094	5,488,131	5,872,300	6,283,361	6,723,196	7,193,820	7,697,387	8,236,204	8,812,739	(0)	(0)	(0)	(0)	(0)
Total Debt Service	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	9,429,630	0	0	0	0	0
Net Cash Flow after Debt Service	(4,725,630)	(4,545,159)	(4,360,067)	(4,170,217)	(3,975,466)	(3,775,666)	(3,570,666)	(3,360,310)	(3,144,437)	(2,922,883)	(2,695,475)	(2,462,040)	(2,222,396)	(1,976,356)	(1,723,729)	7,938,844	8,178,775	8,425,904	8,680,447	8,942,626
Debt Service Coverage Ratio	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.67	0.69										
Total Pre-tax Net Cash Flow *(20 yrs)*	($7,463,900)																			

E 1B: 100% Cash Financing

	Year 0:	Year 1:	Year 2:	Year 3:	Year 4:	Year 5:	Year 6:	Year 7:	Year 8:	Year 9:	Year 10:	Year 11:	Year 12:	Year 13:	Year 14:	Year 15:	Year 16:	Year 17:	Year 18:	Year 19:	Year 20:
et Cash Flow	(85,884,262)	4,704,000	4,884,471	5,069,563	5,259,413	5,454,165	5,653,965	5,858,965	6,069,321	6,285,193	6,506,748	6,734,155	6,967,590	7,207,235	7,453,274	7,705,901	7,938,844	8,178,775	8,425,904	8,680,447	8,942,626
otal Pre-tax Net Cash Flow *(20 yrs)*		$48,096,293																			
IRR @ 100% CASH		4.15%																			
ayback Period *(Pre-tax, undiscounted)*		(18.3) years																			

SE 1C: Combined Equity & Debt Financing

quity Portion	**25.00%**	**$21,471,066**	Amortization	**15** yrs
ebt Portion	**75.00%**	**$64,413,197**	Interest Rate	**7.00%**

	Year 0: 1997/1998	*Year 1: 1999 / 2000*	*Year 2: 2000/2001*	*Year 3: 2001/2002*	*Year 4: 2002/2003*	*Year 5: 2003/2004*	*Year 6: 2004/2005*	*Year 7: 2005/2006*	*Year 8: 2006/2007*	*Year 9: 2007/2008*	*Year 10: 2008/2009*	*Year 11: 2006 / 2007*	*Year 12: 2007 / 2008*	*Year 13: 2008 / 2009*	*Year 14: 2009 / 2009*	*Year 15: 2010 / 2011*	*Year 16: 2011 / 2012*	*Year 17: 2012 / 2013*	*Year 18: 2013 / 2014*	*Year 19: 2014 / 2015*	*Year 20: 2015 / 2016*
et Operating Cash Flow	0	4,704,000	4,884,471	5,069,563	5,259,413	5,454,165	5,653,965	5,858,965	6,069,321	6,285,193	6,506,748	6,734,155	6,967,590	7,207,235	7,453,274	7,705,901	7,938,844	8,178,775	8,425,904	8,680,447	8,942,626
Debt Interest		4,508,924	4,329,493	4,137,502	3,932,071	3,712,261	3,477,063	3,225,402	2,956,125	2,667,998	2,359,702	2,029,826	1,676,858	1,299,182	895,070	462,669	0	0	0	0	0
Debt Principal		2,563,299	2,742,730	2,934,721	3,140,151	3,359,962	3,595,159	3,846,821	4,116,098	4,404,225	4,712,521	5,042,397	5,395,365	5,773,040	6,177,153	6,609,554	{0}	{0}	{0}	{0}	{0}
Total Debt Service		7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	7,072,223	0	0	0	0	0
Net Cash Flow	(21,471,066)	(2,368,223)	(2,187,751)	(2,002,660)	(1,812,810)	(1,618,058)	(1,418,258)	(1,213,258)	(1,002,902)	(787,030)	(565,475)	(338,068)	(104,632)	135,012	381,052	633,678	7,938,844	8,178,775	8,425,904	8,680,447	8,942,626
ebt Service Coverage Ratio		*0.67*	*0.69*	*0.72*	*0.74*	*0.77*	*0.80*	*0.83*	*0.86*	*0.89*	*0.92*	*0.95*	*0.99*	*1.02*	*1.05*	*1.09*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*	*#DIV/0!*
otal Pre-tax Net Cash Flow *(20 yrs)*		$6,426,149																			

ternal Rate of Return *(IRR Pre-Tax)* 1.0%

odified Internal Rate of Return *(MIRR Pre-tax)* 1.4% *(excludes any assumption of project terminal value)*

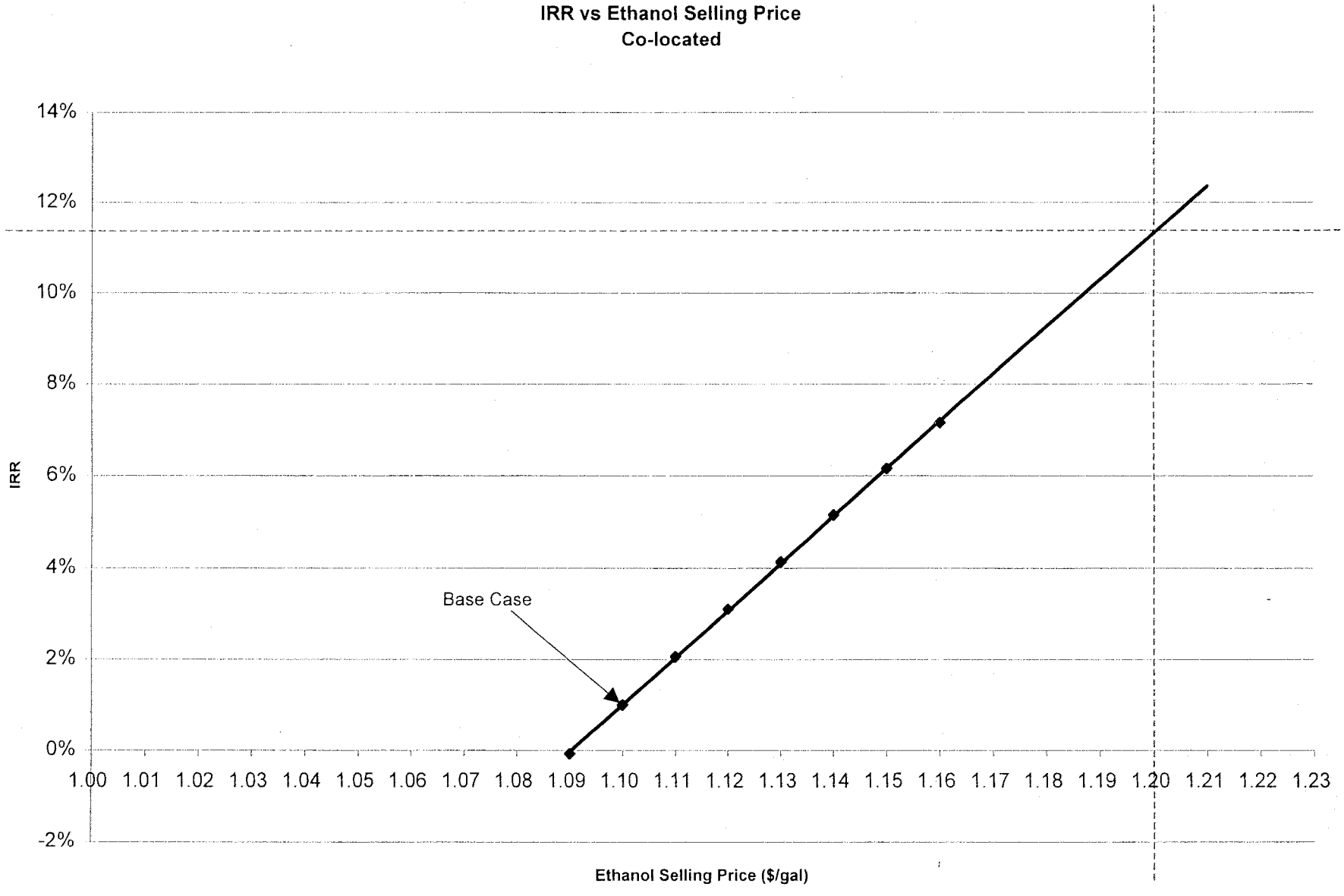
Sensitivity Analysis

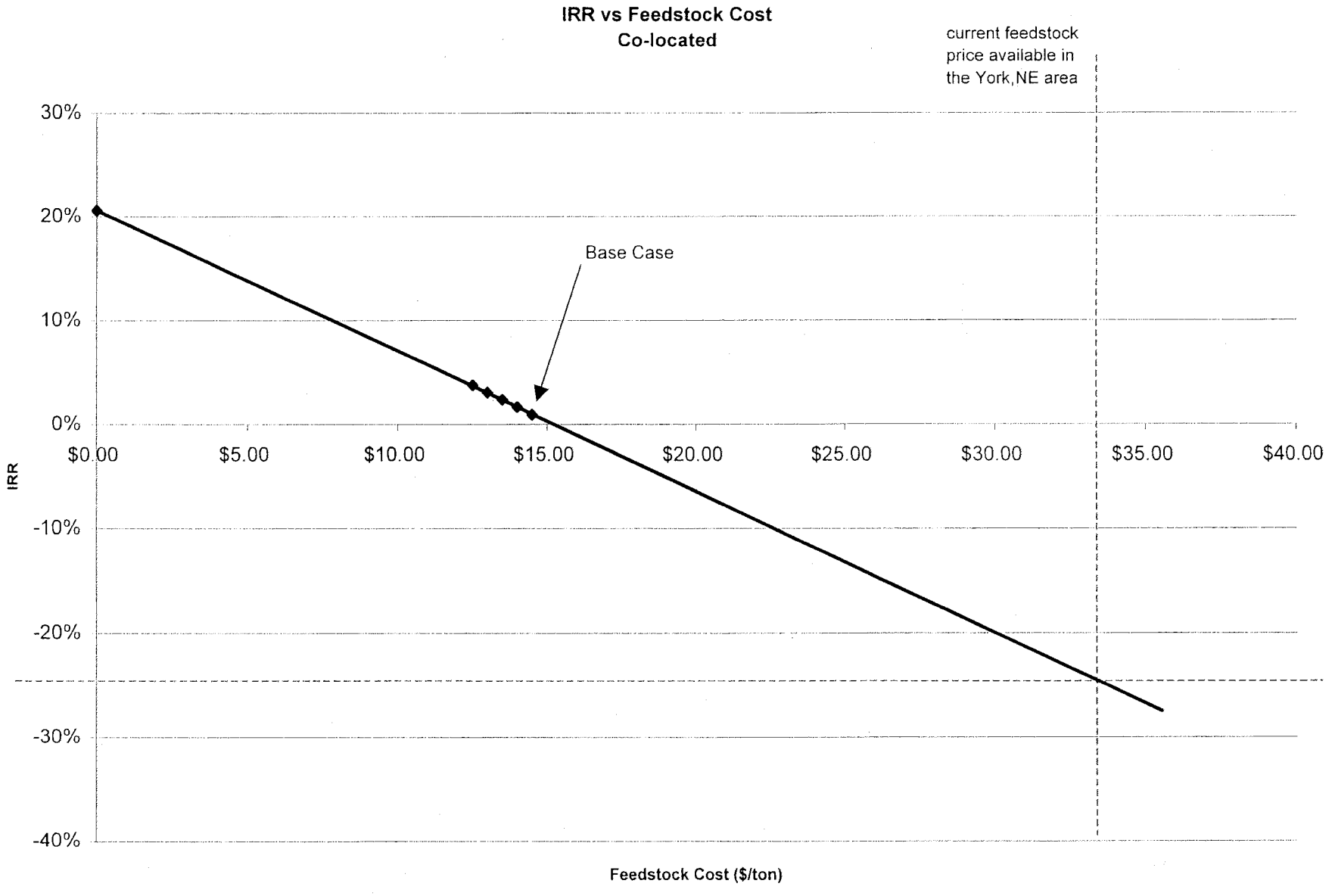
High Plains Corp.
York, NE Co-located
Stover-to-Ethanol Plant

	20 YR. NET CASH FLOW $	RATE OF RETURN	FEED PRICE DRY $/TON	ETHANOL SALE $/GAL	
E1	(3,950,971)	-1%	14.450	1.085	
E2	(491,931)	0%	14.450	1.09	
E3	6,426,149	1%	14.450	1.10	BASE CASE
E4	13,344,229	2%	14.450	1.11	
E5	20,262,308	3%	14.450	1.12	
E6	27,180,388	4%	14.450	1.13	
E7	34,098,468	5%	14.450	1.14	
E8	41,016,548	6%	14.450	1.15	
E9	47,934,628	7%	14.450	1.16	
F1	141,269,327	21%	0.000	1.10	
F2	24,622,979	4%	12.500	1.10	
F3	19,957,125	3%	13.000	1.10	
F4	15,291,271	2%	13.500	1.10	
F5	10,625,417	2%	14.000	1.10	
F6	5,959,563	1%	14.500	1.10	

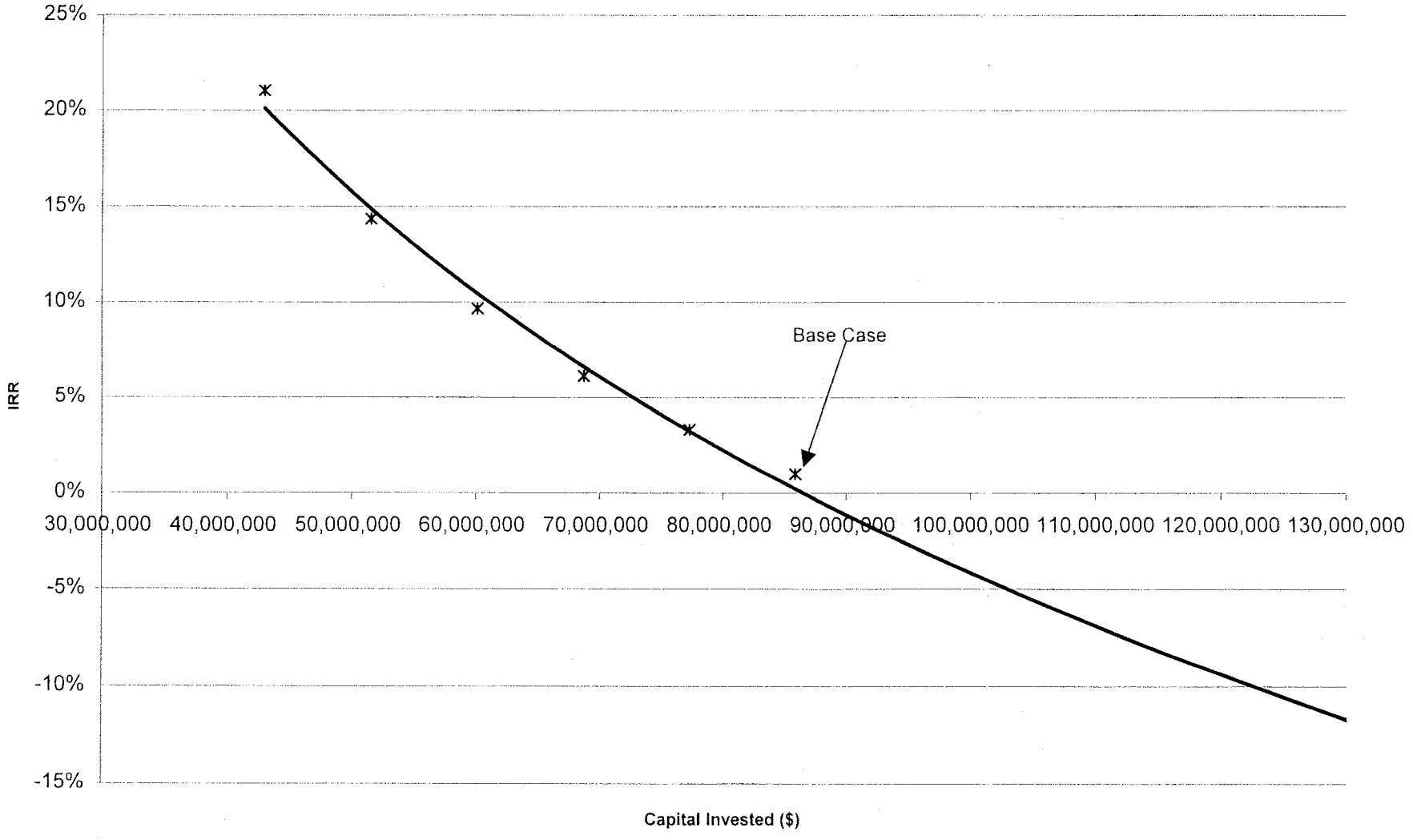
					%	CAPITAL INVEST	$/gal of capacity	
cap1	72,181,553	21%	14.450	1.10	50%	42,942,131	$ 1.67	
cap2	59,030,472	14%	14.450	1.10	60%	51,530,557	$ 2.00	
cap3	45,879,391	10%	14.450	1.10	70%	60,118,983	$ 2.34	
cap4	32,728,310	6%	14.450	1.10	80%	68,707,410	$ 2.67	
cap5	19,577,229	3%	14.450	1.10	90%	77,295,836	$ 3.00	
cap6	6,426,149	1%	14.450	1.10	100%	85,884,262	$ 3.34	BASE CASE
cap7	(6,724,932)	#NUM!	14.450	1.10	110%	94,472,688	$ 3.67	
cap8	(19,876,013)	#NUM!	14.450	1.10	120%	103,061,115	$ 4.00	
cap9	(33,027,094)	#DIV/0!	14.450	1.10	130%	111,649,541	$ 4.34	
cap10	(46,178,175)	#DIV/0!	14.450	1.10	140%	120,237,967	$ 4.67	
cap11	(59,329,255)	#DIV/0!	14.450	1.10	150%	128,826,393	$ 5.00	

					gal per short ton	Ethanol Produced		
p1	(374,068,245)	#DIV/0!	14.450	1.10	37.07	12,873,062	50%	
p2	(297,969,366)	#DIV/0!	14.450	1.10	44.49	15,447,674	60%	
p3	(221,870,488)	#DIV/0!	14.450	1.10	51.90	18,022,287	70%	
p4	(145,771,609)	#DIV/0!	14.450	1.10	59.32	20,596,899	80%	
p5	1,099,227	0%	14.450	1.10	73.63	25,565,901	99.30%	
p6	6,426,149	1%	14.450	1.10	74.15	25,746,124	100%	BASE CASE
p7	82,525,027	12%	14.450	1.10	81.56	28,320,736	110%	
p8	158,623,906	23%	14.450	1.10	88.98	30,895,349	120%	
p9	234,722,785	35%	14.450	1.10	96.39	33,469,961	130%	

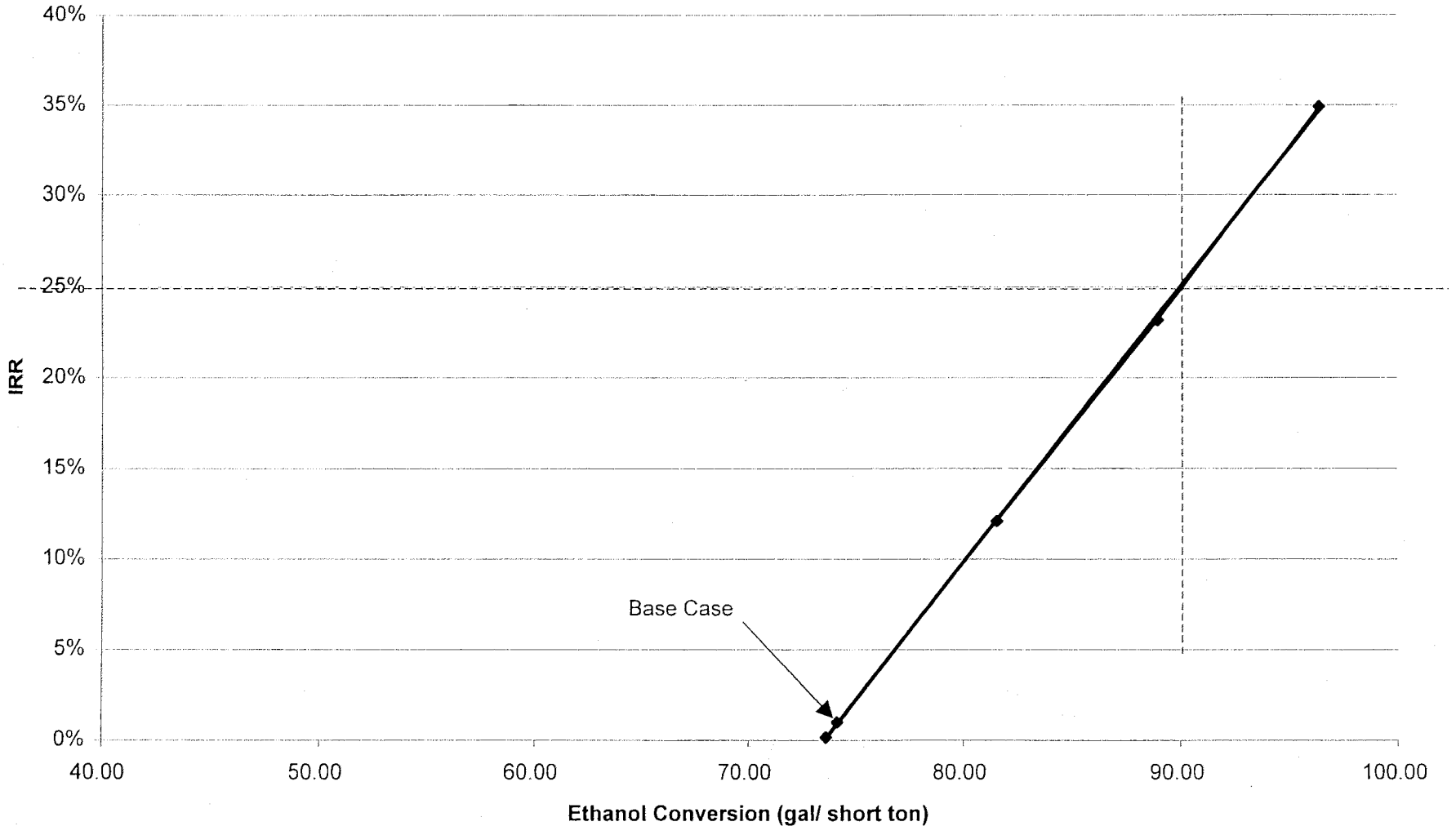

IRR vs Ethanol Selling Price
Co-located
14%
12%
10%
8%
6%
4%
2%
0%
-2%
IRR
Base Case
1.00 1.01 1.02 1.03 1.04 1.05 1.06 1.07 1.08 1.09 1.10 1.11 1.12 1.13 1.14 1.15 1.16 1.17 1.18 1.19 1.20 1.21 1.22 1.23
Ethanol Selling Price ($/gal)


IRR vs Feedstock Cost
Co-located
current feedstock price available in the York,NE area
Base Case
30%
20%
10%
0%
-10%
-20%
-30%
-40%
IRR
$0.00
$5.00
$10.00
$15.00
$20.00
$25.00
$30.00
$35.00
$40.00
Feedstock Cost ($/ton)

IRR vs Capital Invested
Co-located



IRR vs Ethanol Conversion
Co-located



Comparison of Cellulase Sources

Comparison of On-site cellulase production methods

Comparison of On-Site Cellulase Production via Pure Vision Technology and NREL Reference Model

	NREL* M FPU required/yr**	difference	Pure Vision M FPU required/yr
	1,446,984	(50,708)	1,497,692
ng Projection:			
of fuel grade ethanol produced	$ 25,434,849	$ (311,275)	$ 25,746,124
ıtract sale price per gallon	$ 1	$ -	$ 1
Gross Annual Revenue	$ 27,978,334	$ (342,402)	$ 28,320,736
all Ethanol Producer Tax Credit			
@ $ - per gallon	$ -		$ -
Total projected ethanol sales and credit	$ 27,978,334	$ (342,402)	$ 28,320,736
Gross Annual Co-Product Revenue	$ 328,822	$ -	$ 328,822
Gross Sales and Credit	$ 28,307,156	$ (342,402)	$ 28,649,558
rating Expenses:			
tilities	$ 4,792,171	$ 567,400	$ 4,224,771
aw Materials	$ 12,843,241	$ 96,523	$ 12,746,718
rocessing Materials	$ 267,948	$ 66,987	$ 200,961
peration & Maintenance	$ 6,414,114	$ 70,428	$ 6,343,686
roperty Tax @ 0.50% Book Value	$ 486,736	$ 57,315	$ 429,421
epreciation	$ 6,038,644	$ 744,902	$ 5,293,743
Total Operating Expense	$ 30,842,855	$ 1,603,554	$ 29,239,301
et Operating Income	$ (2,535,699)	$ (1,945,956)	$ (589,742)
ɜt Operating Cash Flow	$ 3,502,945	$ (1,201,055)	$ 4,704,000

enzyme cost (cost of production calculated in "$per lb. calcs.") divided by lbs. per year flow rate from mass balance.	$/lb	$ 0.027		$ 0.020
enzyme cost (cost of production calculated in "$per lb. calcs.") divided by million FPU per year required.	$/MFPU	**$ 4.60**		**$ 3.32**

Annual Savings Using PureVision On-Site Enzyme Production	
OVER REFERENCE MODEL:	**$ 1,201,055**

* 45% scale factor applied, SHCF

* * MFPU = million FPU

JDY MODEL WITH REFRENCE MODEL CELLULASE PRODUCTION FOR COMPARISON OF ON-SITE ENZYME PRODUCTION VS. PURCHASE

LOSS OF ETOH PRODUCTION POSSIBLE: 111 kg/hr A

10/27/99

ENZYMATIC HYDROLYSIS - PRO FORMA

ving Assumptions & Input Variables

RRENT SITUATION:

The Pro Forma models an Enzymatic Hydrolysis Ethanol plant using corn stover as the feed stock.

ETHANOL

The plant will convert corn stover to fuel grade ethanol utilizing enzymatic hydrolosis.

Corn stover feed rate of 71,977 kg/hr (str 101), produce estimated total output in

equivalent kilograms of fuel grade ETOH 9,041 kg/hr. = 75,942,299 kg / year (str 515)

gal./short ton= 73.3 3,028 gal/hr = 25,434,849 gal / year

gal./metric ton 80.7

Increase to current York yearly production: 69%

The model assumes renewal of the ethanol excise tax credit of $.54 per gallon to the blender and **NOT** the small producer tax credit of $.10 per gallon through the year 2015 for a total ethanol value of

$1.10 per gallon or **$0.37** per kg and **$ 27,978,334 per year TOTAL Ethanol sales**

CARBON DIOXIDE

Currently, carbon dioxide from the High Plains York fermentations is sold to a CO_2 compression company.

Diverting the CO_2 (stm 550) from the stover plant into this stream for sale as opposed to the atmosphere provides

110,749 kg/hr = 930,294 ton / year with a value of $ 4.13 per metric ton

WITH THIS PROFORMA NO CO_2 IS SOLD. **CO_2 Value/year = $0**

LIGNIN

A Lignin co-product is produced and sold as combustion fuel material. A total amount of lignin in the stream (stm 601B) is

63,778 kg/hr = 535,734 metric ton / year is produced from the process.

The water in the lignin stream must be vaporized at a net BTU cost for the stream (stm 601B). Water vaporized is

43,969 kg/hr = 369,337 metric ton/year is vaporized at 1,100 BTU/lb loss = (107) MM BTU/hr

The remaining 19,809 kg/hr of stream 601B has 24,251 BTU/kg value = 480 MM BTU/hr

Total heating value from stream 601A is 374 MM BTU/hr

Gross Lignin Value/year = $7,848,926

Transport Cost = $7,848,926

Net Lignin Value = $0

METHANE

The digester produces 85% methane @ 353 kg/hr (stm 615) 44,332 BTU/kg CH4

Total heating value from Methane is 16 MM BTU/hr

methane is used in the DDG dryers and based on BTU value of $2.50 MM BTU

METHANE Value/year = $328,822

DIGESTER SLUDGE

The digester produces (stm 623) 0 kg/hr of sludge as fuel = 2,254 BTU/lb

based on 9,845 btu/lb biomass and 70% water in the sludge. = 4,969 BTU/kg

Total heating value from sludge is 0.00 MM BTU/hr

SLUDGE Value/year = $0

Sale of methane and lignin, based on BTU value is **$328,822 per year**

Total projected facility sales would be $28,307,156 per year

APITAL INVESTMENT ASSUMPTIONS

Total capital investment			
Civil Structural		1,500,000	
Area 100		6,146,434	
Area 200		14,955,166	
Area 300		4,028,307	
Area 307		3,714,334	
Area 400		10,353,995	
Area 500		7,515,486	
Area 600		9,824,251	
Area 700		282,716	
Area 800		3,684,612	
Area 900		2,236,491	
Fixed Capital		$64,241,793	
INDIRECTS Prorateable	3.5%	$2,248,463	
Process Development	2.0%	$1,284,836	
Field Expense	8.0%	$5,139,343	
Home Office Constr. Fee	12.0%	$7,709,015	
Contingency	10.0%	$6,424,179	
Start-up, Permits, Fees	3.0%	$1,927,254	
Working Capital per estimate		$1,604,780	1 mos Raw matls. + O&M
Total Plant Cost		$90,579,663	
FEDERAL & STATE GRANTS	10%	($9,057,966)	
Net Capital Investment		**$81,521,697**	

PERATING COST ASSUMPTIONS 8,400 hr/yr

Utilities (Rates based on 25,434,849 gal/yr produced)

	Amount/hr	*Units*	*$/unit*	*Cost /hr.*	**Total Cost /yr**
*Electricity	14,823	Kw-hr	$0.035	$519	$4,358,036
Well water	79,972	kg	$0.000	$0	$0
*Wastewater	39,119	kg	$0.00026	$10	$86,808
*Gypsum waste disposal	1,137	kg	$0.0364	$41	$347,327
		mTon	$1.103	$0	$0
Total Utilities				$570	$4,792,171

**** Quoted by High Plains***

Model Input (.45)

Raw Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Corn Stover DRY (stm 101 less water)	37,500	kg	$0.016	$597.41	$5,018,284
*Sulfuric Acid (stm 710)	860	kg	$0.100	$86.26	$724,592
*Calcium Hydroxide (Lime stm 227)	337	kg	$0.293	$98.70	$829,039
*Ammonia (stm 717)	464	kg	$0.162	$75.17	$631,405
Corn Steep Liquor (stm 735)	909	kg	$0.051	$46.36	$389,452
Nutrients (stm 415)	80	kg	$0.291	$23.31	$195,794
Purchased Cellulase	0	kg	$3.000	$0.00	$0
*Natural Gasoline (stm 701)	391	kg	$0.155	$60.36	$506,988
*Rolling Stock Gasoline	79	kg	$0.155	$12.32	$103,470
*WWT Chemicals	5	kg	$2.237	$11.98	$100,603
*CW Chemicals	17	kg	$1.428	$24.38	$204,791
*BFW Chemicals	73.8	kg	$0.226	$16.65	$139,833
*Boiler Fuel (stm 813)	190	Mbtu	$2.500	$476.07	$3,998,989
Total Raw Materials				$1,529	$12,843,241

Quoted by High Plains

Processing Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
*Antifoam (Corn Oil)	105	kg	$0.304	$32	$267,948
Total Processing Materials				$32	$267,948

Quoted by High Plains

Operations and Maintenance Costs - DRY HANDLING (area 100	each/day		wage	hr/day each	Total Cost /yr.
*Supervisors	0.5	$	20.00	12	$43,800
*Operators	2.0	$	16.00	12	$140,160
*Laborers	8.0	$	16.00	12	$560,640
*Maintenance	2.0	$	16.00	12	$140,160
Operations and Maintenance Costs - HYDROLYSIS/FERMENTATION (area 200, 300, 400, 500, 600)					
*Supervisors	1.0	$	20.00	12	$87,600
*Operators	9.0	$	16.00	8	$420,480
*Laborers	4.0	$	16.00	8	$186,880
*Technicians (Includes Lab.)	3.0	$	16.00	8	$140,160
*Maintenance	3.0	$	16.00	8	$140,160
Operations and Maintenance Costs - Utilities (area 700, 800, 900)					
*Supervisors	0.5	$	20.00	12	$21,900
*Operators	3.0	$	16.00	8	$70,080
*Laborers	1.0	$	16.00	8	$23,360
*Technicians	1.0	$	16.00	8	$23,360
*Maintenance	2.0	$	16.00	8	$46,720

Quoted by High Plains Standard HPY shifts are 12 hours.

Total Operations and maintenance labor costs $2,045,460

Other Operations and Maintenance Costs			
Payroll Overhead	35% of operating labor	$	715,911
Maintenance Costs	2% of plant cost	$	1,284,836
Operating Supplies	0.25% of plant cost	$	160,604
Environmental	0.50% of plant cost	$	321,209
Local Taxes	1% of plant cost	$	642,418
Insurance	0.50% of plant cost	$	321,209
Overhead Costs	40% of labor, supervision,maint cost	$	818,184
Administrative Costs	1% of annual sales (less tax credits)	$	104,283
Distribution and Sales	0.5% of annual sales (less tax credits)	$	-
Total O&M Costs			$6,414,114

THER MODEL ASSUMPTIONS

verage prevailing market price of fuel grade ETOH:		$0.37	per kg
ssumes renewal of the ethanol excise tax credit of $.54 per gallon		$ 1.10	per gallon
d the small producer tax credit of $.10 per gallon through the year 2007			
Value of CO_2 produced		$ 4.13	per metric ton
Price for Electricity		$ 0.035	per KWhr
Gas price per million BTU		$ 2.500	per MM BTU
		68%	Dry matter
orn Stover feedstock cost- **dry basis/short ton**	$ 14.45	$0.016	per kg
		$15.93	per metric ton
ant on-stream factor		0.959	
ant operating hours per year		8,400	
epreciable Life of Capital Equipment		15	years
verage annual commodity escalation rate:		3.0%	
verage annual cost escalation rate:		3.0%	

**** Quoted by High Plains***

There are no land acquisiton costs included.
There are no off site costs included (e.g. public road improvements, extensions of power, water, telephone services)
There is a source of qualified construction personnel within daily driving distance of the site
There exist adequate roads and rail roads to allow equipment delivery.
The costs for air and water permits are not included.
Soils are adequate for conventional foundation designs.

stimated Equipment Costs for Reference Model Scaled Down 45% with On-Site Enzyme Production and SHCF

all cells are automatically updated from file Equipa with the exception of red letter areas

Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Install Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description	3442 WORK	
C-101	1	0	Bale conveyor	AREA0100	154	170	1.11	$15,000	1999	$15,000	0.6	$15,927	1.5	$24,551	$ 15,927	wire mesh conveyor 60" wide 20' long	WC101	11.93
C-102	1	0	Radial Stacker Conveyor	AREA0100	154	170	1.11	$159,830	1999	$159,830	0.6	$169,708	1.5	$261,604	$ 169,708	16 degree, 36" x 200' radial stacker, 750 ton/hr, 75 HP	WC102	44.74
C-103	1	0	Breaker Infeed Belt	AREA0100	154	170	1.11	$49,500	1999	$49,500	0.6	$52,559	1.5	$81,020	$ 52,559	84" x 35' rubber belt cleated infeed conveyor, 10 HP, TEFC drive motor with guard	WC103	5.97
C-104	1	0	1st Shredder Conveyor	AREA0100	154	170	1.11	$25,650	1999	$25,650	0.6	$27,235	1.5	$41,983	$ 27,235	60" wide x 25' long, 10 HP, TEFC drive with guard	WC104	5.97
C-105	1	0	1st Infeed Belt	AREA0100	154	170	1.11	$38,500	1999	$38,500	0.6	$40,879	1.5	$63,015	$ 40,879	60" wide x 30' long, 10 HP, TEFC drive with guard	WC105	11.93
C-106	1	0	2nd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.5	$48,285	$ 31,323	48" wide x 20' long, 7.5 HP, TEFC drive with guard	WC106	4.47
C-107	1	0	2nd Infeed Belt	AREA0100	154	170	1.11	$27,500	1999	$27,500	0.6	$29,200	1.5	$45,011	$ 29,200	48" wide x 30' long, 5 HP, TEFC drive with guard	WC107	2.98
C-108	1	0	3rd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.5	$48,285	$ 31,323	48" wide x 20' long, 10 HP, TEFC drive with guard	WC108	5.97
C-109	1	0	Feed Screw Conveyor	AREA0100	225,140	562,850	2.50	$31,700	1997	$31,700	0.6	$54,932	1.5	$86,351	$ 56,018	14" dia. 250' long	WC109	53.75
M-101	2	0	Truck Scale	AREA0100	96	72	0.75	$10,000	1999	$20,000	0.6	$16,829	1.5	$25,244	$ 16,829	96 deliveries /scale/12hr		
M-102	1	0	Receiving Pad	AREA0100	250,000	250,000	1.00	$2,083,500	1999	$2,083,500	0.6	$2,083,500	1.0	$2,083,500	$ 2,083,500	250,000 ft2 concrete pad, 9" thick with drainage		
M-103	6	1	Front End Loader	AREA0100	159,948	159,948	1.00	$156,000	1998	$1,092,000	0.6	$1,092,000	1.2	$ 1,326,016	$ 1,105,013	run on gasoline		
M-104	3	0	Bale Breaker	AREA0100	154	170	1.11	$250,000	1999	$750,000	0.6	$796,352	1.2	$955,622	$ 796,352	30 HP each	WM104	53.69
M-105	1	0	Primary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.2	$135,444	$ 112,870	250 HP, 1200 rpm, hammermill	WM105	149.14
M-106	1	0	Secondary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.5	$169,304	$ 112,870	250 HP, 1200 rpm, hammermill	WM106	149.14
M-107	1	0	Shred Bunker	AREA0100	600,000	600,000	1.00	$700,000	1999	$700,000	0.6	$700,000	1.0	$700,000	$ 700,000	200x100x30ft bunker with three walls, 3 days shred storage		
M-108	1	0	Storm Runoff Pond	AREA0100	1,747,767	1,747,767	1.00	$51,198	1998	$51,198	0.6	$51,198	1.0	$51,198	$ 51,808	200 x 150 x 8 ft, 240,000ft3		
										weighted averages:	0.60		1.13					499.68
A100										Subtotal		$5,315,978		$5,418,705	$6,146,434	$5,433,414		
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.3	$3,181,636	($2,964,798)	is installed cost savings		
												Cost Base Year =		1999				
A-201	1	0	In-line Sulfuric Acid Mixer	STRM0214	55,308	23,725	0.43	$1,900	1997	$1,900	0.48	$1,266	1.2	$1,585	$1,291	Static Mixer, 110 gpm total flow		
A-202	1	0	In-line NH3 Mixer	STRM0244	53,630	18,317	0.34	$1,500	1997	$1,500	0.48	$896	1.2	$1,122	$913	Static Mixer, 82 gpm total flow		
A-209	1	0	Overliming Tank Agitator	STRM0228	167,050	102,608	0.61	$19,800	1997	$19,800	0.51	$15,442	1.2	$19,345	$15,748	Top Mounted, 1800 rpm, 15 hp	WT209	8.39
A-224	1	0	Reacidification Tank Agitator	STRM0239	167,280	102,752	0.61	$65,200	1997	$65,200	0.51	$50,851	1.2	$63,702	$51,857	Top-Mounted, 1800 rpm, 54 hp	WT224	25.17
A-232	1	0	Reslurrying Tank Agitator	STRM0250	358,810	167,795	0.47	$36,000	1997	$36,000	0.51	$24,432	1.2	$30,606	$24,915	Top-Mounted, 1800 rpm, 25 hp	WT232	13.98
A-235	1	0	In-line Acidification Mixer	STRM0236	164,570	101,104	0.61	$2,600	1997	$2,600	0.48	$2,058	1.2	$2,578	$2,099	Static-Mixer, 440 gpm total flow		
C-201	1	0	Hydrolyzate Screw Conveyor	STRM0220	225,140	101,493	0.45	$59,400	1997	$59,400	0.78	$31,908	1.5	$50,158	$32,539	18" dia. 33' long, 3420 cfh max flow, 23 hp	WC201	13.72
C-202	1	0	Wash Solids Screw Conveyor	STRM0225	196,720	165,453	0.84	$23,700	1997	$23,700	1	$19,933	1.5	$31,334	$20,327	18" dia. 16' long, 3420 cfh max flow	WC202	16.70
C-225	1	0	Lime Solids Feeder			0		$3,900	1997	$3,900	1	$3,900	1.5	$6,131	$3,977	6" dia., 63 cfh, 3150 lb/hr max flow	WC225	0.15
H-200	1	0	Hydrolyzate Cooler	AREA0200	1,988	895	0.45	$45,000	1997	$45,000	0.51	$29,947	2.2	$66,543	$30,539	Fixed Tube Sheet, 900 sf, 20" dia. X 20' long		
H-201	1	1	Beer Column Feed Economizer	AREA0201	5,641	5,641	1.00	$139,350	1999	$278,700	0.68	$278,700	2.2	$607,278	$278,700	TEMA type AES shell and tube 5641 sf, 42" dia x 20' long		
M-202	1	0	Prehydrolysis Reactor	STRM0217	270,034	121,514	0.45	$12,461,841	1998	$12,461,841	0.78	$6,684,746	1.5	$10,146,612	$6,764,408	Vertical Screw, 10 min residence time	WM105	353.16
P-201	1	1	Sulfuric Acid Pump	STRM0710	1,647	414	0.25	$4,800	1997	$9,600	0.79	$3,228	2.8	$9,190	$3,291	2 gpm, 245 ft. head	WP201	0.40
P-209	1	1	Overlimed Hydrolyzate Pump	STRM0228	167,050	102,608	0.61	$10,700	1997	$21,400	0.79	$14,561	2.8	$41,458	$14,849	448 gpm, 150 ft. head	WP209	18.01
P-222	1	1	Filtered Hydrolyzate Pump	STRM0230	162,090	101,614	0.63	$10,800	1997	$21,600	0.79	$14,936	2.8	$42,526	$15,231	448 gpm, 150 ft head	WP222	17.83
P-223	1	0	Lime Unloading Blower	STRM0227	547	337	0.62	$47,600	1998	$47,600	0.5	$37,340	1.4	$52,898	$37,785	3341 cfm, 6 psi, 10,024 lb/hr	WP223	4.10
P-224	1	1	Hydrolysis Feed Pump	STRM0250	160,000	167,795	1.05	$64,934	1999	$129,868	0.6	$133,628	1.2	$160,354	$133,628	740 gpm, 240 ft head	WP224	119.31
P-225	1	1	ISEP Elution Pump	STRM0243	52,731	18,005	0.34	$7,900	1997	$15,800	0.79	$6,761	2.8	$19,249	$6,894	104 gpm, 150 ft head	WP225	3.92
P-226	1	1	ISEP Reload Pump	STRM0246	164,080	100,802	0.61	$8,700	1997	$17,400	0.79	$11,841	2.8	$33,714	$12,075	445 gpm, 150 ft head	WP226	17.92
P-227	1	1	ISEP Hydrolyzate Feed Pump	STRM0221	160,290	98,157	0.61	$10,700	1997	$21,400	0.79	$14,526	2.8	$41,359	$14,814	432 gpm, 150 ft head	WP227	16.81
P-239	1	1	Reacidified Liquor Pump	STRM0239	167,280	102,752	0.61	$10,800	1997	$21,600	0.79	$14,698	2.8	$41,847	$14,988	450 gpm, 100 ft head	WP239	12.09
S-202	3	0	Pre-IX Belt Filter Press	SOLD0220	57,000	57,000	1.00	$200,000	1998	$600,000	0.39	$600,000	1.4	$850,010	$607,150	Use 3 units for 45% of the flow as recommended by the vendor	WS202	19.69
S-221	1	0	ISEP	STRM0240	210,005	98,157	0.47	$2,058,000	1997	$2,058,000	0.33	$1,601,194	1.2	$1,959,422	$1,632,851	10 chambers (39" dia. X 84" high), 4" dia. Valve - Weak Base Resin	WS221	2.98
S-222	1	0	Hydroclone & Rotary Drum Filter	STRM0229	5,195	1,137	0.22	$165,000	1998	$165,000	0.39	$91,224	1.4	$129,235	$92,311	Hydrocyclone and Vacuum Filter for 453 gpm	WS222	11.93
S-227	1	0	LimeDust Vent Baghouse	STRM0227	548	337	0.61	$32,200	1997	$32,200	1	$19,778	1.5	$30,254	$20,169	3750 cfm, 625 sf, 6 cfm/sf		
T-201	1	0	Sulfuric Acid Storage	STRM0710	1,647	860	0.52	$5,760	1996	$5,760	0.71	$3,633	1.7	$6,283	$3,751	2000 gal., 24 hr. residence time, 90% wv, 5.5ft diam. X 11ft		
T-203	1	0	Blowdown Tank	STRM0217	270,300	121,514	0.45	$64,100	1997	$64,100	0.93	$30,475	1.7	$52,061	$31,078	7000 gal., 11' dia x 30' high, 10 min. res. time, 75% wv, 15 psig		
T-209	1	0	Overliming Tank	STRM0228	167,050	102,608	0.61	$71,000	1997	$71,000	0.71	$50,232	1.8	$90,186	$51,225	29850 gal., 16' dia. X 32' high, 1 hr. res. time, 90% wv, 15 psig		
T-220	1	0	Lime Storage Bin	STRM0227	548	548	1.00	$69,200	1997	$69,200	0.46	$69,200	1.8	$124,243	$70,568	4455 cf, 14' dia x 25' high, 1.5x rail car vol., atmospheric, 15 day storage max		
T-224	1	0	Reacidification Tank	STRM0239	102,752	102,752	1.00	$111,889	1999	$111,889	0.51	$111,889	1.8	$196,992	$111,889	120,000 gal., 28' dia x 28' high, 4 hr. res. time, 90% wv, atmospheric		
T-232	1	0	Slurrying Tank	STRM0250	358,810	167,795	0.47	$44,800	1997	$44,800	0.71	$26,117	1.8	$46,890	$26,633	11300 gal., 13' dia. X 25' high, 15 min. res. time, 90% wv		
0	0	0	0	0	0	0	0.00	$0	1999	$0	0	$0	-	$0	$0	0		
										weighted averages:	0.70		1.48					676.27
A200										Subtotal		$16,527,758		$9,999,337	$14,955,166	$10,128,493		
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.5	$15,025,380	$70,213	is installed cost savings		

A-300	8	0	Fermentor Agitators	GALLONS	962,651	750,000	0.78	$19,676	1996	$157,408	0.51	$138,592	1.2	$175,799	$143,110	Side Mounted, 2 per vessel, 60 hp each, 0.15 hp/1000 gal	WT300	201.34
A-301	1	0	Seed Hold Tank Agitator	STRM0304	41,777	17,529	0.42	$12,551	1996	$12,551	0.51	$8,060	1.2	$10,223	$8,322	Top Mounted, 1800 rpm, 10 hp, 0.1 hp/1000 gal	WT301	5.59
A-304	2	0	4th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$11,700	1997	$23,400	0.51	$15,026	1.2	$18,824	$15,323	Top Mounted, 1800 rpm, 3 hp, 0.3 hp/1000 gal	WT304	3.36
A-305	2	0	5th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$10,340	1996	$20,680	0.51	$13,280	1.2	$16,845	$13,713	Top Mounted, 1800 rpm, 9 hp, 0.1 hp/1000 gal	WT305	10.07
A-306	1	0	Beer Well Agitator	STRM0502	381,700	173,737	0.46	$10,100	1997	$10,100	0.51	$6,761	1.2	$8,469	$6,894	Top Mounted, 1800 rpm, 2 hp, 0.3 hp/1000 gal	WT306	1.12
F-300	4	0	Fermentors	GALLONS	750,000	750,000	1.00	$326,203	1999	$1,304,812	0.71	$1,304,812	1.8	$2,297,260	$1,304,812	750,000 gal. each, 2 day residence total, 90% wv, API, atmospheric, 50' f x 51'		
F-301	2	0	1st Fermentation Seed Fermentor	None		0	0.45	$14,700	1997	$29,400	0.93	$13,991	2.8	$39,948	$14,267	9 gal, jacketed, agitated, 1' dia., 1.5' high, 15 psig		
F-302	2	0	2nd Fermentation Seed Fermentor	None		0	0.45	$32,600	1997	$65,200	0.93	$31,027	2.8	$88,592	$31,640	90 gal., jacketed, agitated, 2' 3" dia., 3' high, 2.5 psig		
F-303	2	0	3rd Fermentation Seed Fermentor	None		0	0.45	$81,100	1997	$162,200	0.93	$77,186	2.8	$220,394	$78,712	900 gal., jacketed, agitated, 5' dia, 6.5' high, 2.5 psig		
F-304	2	0	4th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$39,500	1997	$79,000	0.93	$35,225	1.7	$60,174	$35,921	9000 gal., 9' dia x 19' high, atmospheric		
F-305	2	0	5th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$147,245	1998	$294,490	0.51	$189,107	1.8	$336,910	$191,360	90000 gal., API, atmospheric 25'f x 25'		
H-300	4	1	Fermentation Cooler	QHX300EA	67,820	25,053	0.37	$4,000	1997	$20,000	0.78	$9,198	2.2	$20,438	$9,380	4 exchangers at 221 sf, U=300 BTU/hr sf F LMTD = 22.9°F plate and frame		
H-301	1	0	Fermentation Seed Hydrolyzate Cooler	AREA0301	773	318	0.41	$15,539	1998	$15,539	0.78	$7,778	2.2	$17,151	$7,871	348 sf, 300 BTU/hr sf F		
H-302	1	0	Fermentation Pre-Cooler	AREA0302	3,765	828	0.22	$25,409	1998	$25,409	0.78	$7,797	2.2	$17,193	$7,890	828 sf total, plate and frame		
H-304	1	0	4TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$3,300	1997	$3,300	0.83	$1,580	1.2	$1,934	$1,611	12 sf, 1" sch 40 pipe, 105 BTU/hr sf F		
H-305	1	0	5TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$18,800	1997	$18,800	0.98	$7,881	1.2	$9,644	$8,037	138 sf, 2" sch 40 pipe, 92 BTU/hr sf F		
P-300	4	1	Fermentation Recirc./Transfer Pump	QHX300EA	67,737	55,505	0.82	$8,000	1997	$40,000	0.79	$34,177	2.8	$97,307	$34,852	844 gpm @ 150 ft sized based on heating rate	WP300	104.49
P-301	1	1	Fermentation Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$22,194	1998	$44,388	0.7	$24,168	1.4	$34,238	$24,456	280 gpm @ 150 ft head	WP301	5.95
P-302	2	0	Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$54,088	1998	$108,176	0.7	$58,898	1.4	$83,440	$59,600	504 gpm total, 252 gpm each, 100 ft head	WP302	7.14
P-306	1	1	Beer Transfer Pump	STRM0502	381,701	173,737	0.46	$17,300	1997	$34,600	0.79	$18,579	2.8	$52,899	$18,947	790 gpm each, 171 ft head	WP306	34.47
T-301	1	0	Fermentation Seed Hold Tank	STRM0304	41,777	17,529	0.42	$161,593	1998	$161,593	0.51	$103,767	1.8	$184,870	$105,003	105000 gal., API atmospheric		
T-306	1	0	Beer Well	STRM0502	129,000	183,467	1.42	$111,889	1999	$111,889	0.51	$133,906	1.8	$235,756	$133,906	192,518 gal., 32' dia x 32' high, 4 hr. res. time, 95% wv, atmospheric		
										weighted averages:	0.68		1.79					373.53
A300										Subtotal	$2,742,935		$2,240,795		$4,028,307	$2,255,629			
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)				1.3	$8,218,509	$4,190,202	is installed cost savings		
A-307	8	0	Enzymatic Hydrolysis Tank Agitators	STRM0302B	157,136	157,136	1.00	$19,676	1996	$157,408	0.51	$157,408	1.2	$199,666	$162,539	two side mounted 75 hp agitators / tank, 0.4hp/1000 gal.	WT307	251.67
H-307	12	0	Enzymatic Hydrolysis Tank Heater	STRM0302B	157,136	157,136	1.00	$15,000	1999	$180,000	0.78	$180,000	2.2	$392,214	$180,000	65 ft2 double pipe		
H-308	1	0	Pre-hydrolyzate cooler	STRM0302	145,536	145,536	1.00	$25,000	1999	$25,000	0.78	$25,000	2.2	$54,474	$25,000	481 ft2, parallel double pipe		
P-308	8	1	Hydrolyzer Bottoms Pump	STRM0302B	157,136	157,136	1.00	$121,690	1999	$1,095,210	0.6	$1,095,210	1.2	$1,314,252	$1,095,210	3000 GPM each Disc flow pumps, 245ft head	WP308	1,744.94
T-307	4	0	Enzymatic Hydrolysis Tank	STRM0302B	750,000	375,000	0.50	$326,203	1999	$1,304,812	0.6	$860,855	2.0	$1,753,728	$860,855	375,000 gallons, 24 hour residence time, 2 side mounted agitators cone bottom, concrete base, bottom outlet through the concrete, 30o cone		
0	0	0	0	0	0	0	0.00	$0	1999	$0	0	$0	-	$0	$0	0		
										weighted averages:	0.61		1.60					1,996.61
Area 307										Subtotal	$2,762,430		$2,316,473		$3,714,334	$2,323,604			
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)				-	$0	($3,714,334)	is installed cost savings		
																$475,868	**sizes not updated to reflect 25% increase, but costs and energy consumed are upd**		
A-400	11		Cellulase Fermentor Agitators	GALLONS	150,000	117,779.84	0.79	$ 200,000	1999	$2,200,000	0.51	$ 1,944,743	1.2	$2,388,960	$1,944,743	125 hp / agitator -- 1 agitator/vessel	WT400	745.70
F-400	11		Cellulase Fermentors	GALLONS	88,335	117,779.84	1.33	$ 179,952	1998	$1,979,472	0.71	$ 2,428,040	1.8	$4,325,765	$2,456,975	88335 gal, 2.5 psig, cooling coils in tank costed as H400, 40 ft. height, 20 ft. diameter		
F-401	3		1st Cellulase Seed Fermentor	STRM0433	2,790	1,242.43	0.45	$ 22,500	1997	$67,500	0.93	$ 31,810	2.0	$64,878	$32,439	11 gal / 15 psig / Jacketed / Agitator		
F-402	3		2nd Cellulase Seed Fermentor	STRM0433	2,790	1,242.43	0.45	$ 54,100	1997	$162,300	0.93	$ 76,486	2.0	$155,996	$77,998	221 gal / 15 psig / Jacketed /Agitator	WT402	159.77
F-403	3		3rd Cellulase Seed Fermentor	STRM0433	2,790	1,242.43	0.45	$ 282,100	1997	$846,300	0.93	$ 398,829	2.0	$813,429	$406,715	4417 gal / 15 psig / Jacketed /Agitator		
H-400	11		Cellulase Fermentation Cooler	QHX400EA	236,668	117,779.84	0.50	$ 34,400	1997	$378,400	0.78	$ 219,562	2.2	$487,878	$223,903	Immersible Coil 205 ft2 each		
M-401	5	1	Fermentor Air Compressor Package	STRM0440	80,455	107,273.33	1.33	$ 229,000	1999	$1,374,000	0.34	$ 1,515,186	1.3	$1,969,742	$1,515,186	7946 scfm each, 50 psig outlet, 1277 hp each, includes starter	WM401	6,810.67
P-400	1	1	Cellulase Transfer Pump	STRM0420	40,543	15,467.03	0.38	$ 9,300	1997	$18,600	0.79	$ 8,687	2.8	$24,735	$8,859	58 GPM / 100 ft. head	WP400	2.10
P-401	1	1	Cellulase Seed Pump	STRM0433	2,790	1,242.43	0.45	$ 12,105	1998	$24,210	0.70	$ 13,742	1.2	$16,687	$13,906	24 gpm / 1 hp	WP401	0.37
P-405	1	1	Media Pump	STRM0416	586	266.85	0.46	$ 8,300	1997	$16,600	0.79	$ 8,917	2.8	$25,388	$9,093	21 Gpm/100 Ft Head	WP405	0.12
P-420	1	1	Anti-foam Pump	STRM0417	227	104.85	0.46	$ 5,500	1997	$11,000	0.79	$ 5,976	2.8	$17,013	$6,094	4 gpm / 75 ft head	WP420	0.02
T-405	1		Media-Prep Tank	STRM0416	586	266.85	0.46	$ 64,600	1997	$64,600	0.71	$ 36,955	1.7	$63,130	$37,685	2083 Gal / 1.17 hp Agitator	WT402	0.87
T-420	1		Anti-foam Tank	STRM0417	227	104.85	0.46	$ 402	1998	$402	0.71	$ 232	1.7	$394	$235	67 gal, 3 hr. residence time		
												area install factor		1.5					7,719.61
A400										Subtotal	$7,143,384		$6,689,166		$10,353,995	$6,733,832			
															$10,353,995				

D-501	1	0	Beer Column	DIAMD501	4	2	0.56	$636,976	1996	$636,976	0.78	$402,792	2.1	$873,434	$415,921	7'6" DIA, 32 ACTUAL TRAYS, NUTTER V-GRID TRAYS			
D-502	1	0	Rectification Column	S510S521	56,477	26,744	0.47	$525,800	1996	$525,800	0.78	$293,491	2.1	$636,421	$303,058	8' dia.(rect)., 4' dia. (strip) x 18" T.S., 60 act. Trays, 60% eff., Nutter V-Grid trays			
E-501	1	0	1st Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,676	1996	$435,676	0.68	$435,676	2.1	$944,742	$449,877	22278 sf each., 135 BTU/hr sf F			
E-502	1	0	2nd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.1	$944,685	$449,850	22278 sf., 170 BTU/hr sf F			
E-503	1	0	3rd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.1	$944,685	$449,850	22278 sf each., 170 BTU/hr sf F			
H-501	1	0	Beer Column Reboiler	QRFD0501	-7,863,670	-3,723,722	0.474	$158,374	1996	$158,374	0.68	$95,263	2.2	$214,340	$98,368	Fixed TS, 6602 sf, 31" dia., 20' long, 178 BTU/hr sf F			
H-502	1	0	Rectification Column Reboiler	QRFD0502	-987,427	-467,581	0.474	$29,600	1997	$29,600	0.68	$17,805	2.2	$39,563	$18,157	Thermosyphon, 512 sf, 15" dia., 20' long, 130 BTU/hr sf F			
H-504	1	0	Beer Column Condenser	QCND0501	277,820	131,557	0.474	$29,544	1996	$29,544	0.68	$17,771	2.2	$39,984	$18,350	Floating Head, 418 sf, 15" dia., 22' long, 92 BTU/hr sf F			
H-505	1	0	Rectification Column Condenser	QCND0502	4,905,410	2,322,883	0.474	$86,174	1996	$86,174	0.68	$51,834	2.2	$116,626	$53,524	Fixed TS, 1969 sf, 29" dia, 20' long, 157 BTU/hr sf F			
H-512	1	1	Beer Column Feed Interchange	AREA0512	909	430	0.474	$19,040	1996	$38,080	0.68	$22,905	2.2	$51,537	$23,652	431 sf, 200 BTU/hr sf F			
H-517	1	1	Evaporator Condenser	QHET0517	6,764,222	3,203,095	0.47	$121,576	1996	$243,152	0.68	$146,257	2.2	$329,077	$151,024	Fixed TS, 3906 sf, 29" dia., 20' long, 220 BTU/hr sf F			-
M-503	1	0	Molecular Sieve (9 pieces)	STRM0515	20,491	9,703	0.47	$2,700,000	1998	$2,700,000	0.7	$1,599,964	1.0	$1,619,030	$1,619,030	Superheater, twin mole sieve columns, product cooler, condenser, pumps, vacuum source.	WM503	55.00	
P-501	1	1	Beer Column Bottoms Pump	P501FLOW	5,053	2,200	0.44	$42,300	1997	$84,600	0.79	$43,861	2.8	$124,881	$44,728	2200 gpm, 150 ft head	WP501	84.65	
P-503	1	1	Beer Column Reflux Pump	QCND0501	277,820	131,557	0.47	$1,357	1998	$2,714	0.79	$1,504	2.8	$4,248	$1,522	6 gpm, 140 ft head	WP503	0.22	
P-504	1	1	Rectification Column Bottoms Pump	STRM0516	31,507	15,530	0.49	$4,916	1998	$9,832	0.79	$5,622	2.8	$15,884	$5,689	76 gpm, 158 ft head	WP504	2.80	
P-505	1	1	Rectification Column Reflux Pump	QCND0502	4,906,301	2,323,304	0.47	$4,782	1998	$9,564	0.79	$5,299	2.8	$14,970	$5,362	207 gpm, 110 ft head	WP505	5.14	
P-511	2	1	1st Effect Pump	STRM0525	278,645	133,617	0.48	$19,700	1997	$59,100	0.79	$33,069	2.8	$94,155	$33,723	1137 gpm each, 110 ft head	WP511	67.89	
P-512	1	1	2nd Effect Pump	STRM0528	91,111	45,390	0.50	$13,900	1997	$27,800	0.79	$16,032	2.8	$45,646	$16,349	599 gpm, 110 ft head	WP512	17.37	
P-513	2	1	3rd Effect Pump	STRM0531	48,001	23,814	0.50	$8,000	1997	$24,000	0.79	$13,795	2.8	$39,276	$14,068	196 gpm each, 110 ft head	WP513	12.54	
P-514	1	1	Evaporator Condensate Pump	STRM534A	140,220	69,285	0.49	$12,300	1997	$24,600	0.79	$14,095	2.8	$40,131	$14,374	293 gpm, 125 ft head	WP514	9.20	
P-515	1	1	Scrubber Bottoms Pump	STRM0551	15,377	7,427	0.48	$2,793	1998	$5,586	0.79	$3,143	2.8	$8,881	$3,181	31 gpm, 104 ft head	WP515	0.84	
P-517	1	1	Kill Tank Bottoms Pump	STRM0518	5,053	660	0.13	$42,300	1997	$84,600	0.79	$16,944	2.8	$48,242	$17,279	660gpm, 72 ft head	WP517	12.19	
T-503	1	0	Beer Column Reflux Drum	QCND0501	277,820	131,557	0.47	$11,900	1997	$11,900	0.93	$5,938	1.7	$10,144	$6,055	164 gal, 15 min res. Time, 50% wv, 2'6" dia., 5' long, 25 psig			
T-505	1	0	Rectification Column Reflux Drum	QCND0502	4,906,301	2,323,304	0.47	$45,600	1997	$45,600	0.72	$26,621	1.7	$45,476	$27,147	6225 gal, 15 min res time, 50% wv, 7' dia, 22' long, 25 psig			
T-512	1	0	Vent Scrubber	STRM0523	16,523	9,788	0.53	$99,000	1998	$99,000	0.78	$60,197	1.7	$102,043	$60,915	5' dia x 25' high, 4 stages, plastic Jaeger Tri-Packing			
T-513	1	0	Kill Tank	STRM0518	149,897	149,897	1.00	$99,920	1999	$99,920	0.78	$99,920	1.7	$167,384	$99,920	18 psig, 30 min. res. time			
										weighted averages:	0.72		1.7					267.85
A500										Subtotal	$6,343,492	$4,301,097		$7,515,486	$4,400,972				
										2000lpd x .45 (current year cost with area weighted-average scale exponent applied)			1.7	$6,765,614	-$749,872	is installed cost savings			
C-601	1	0	Lignin conveyor	STRM0601B	225,140	225,140	1.00	$31,700	1997	$31,700	0.60	$31,700	1.5	$49,832	$32,327	14" dia. 100' long	WC109	21.50	
M-613	1	0	Syrup Sprayer	STRM0531	22,372	22,372	1.00	$1,000	1999	$1,000	0.3	$1,000	1.2	$1,200	$1,000	100 GPM syrup sprayer			
M-614	1	0	Lignin Loadout	STRM0601A	63,778	0	0.00	$41,200	1999	$41,200	0.3	$0	1.0	$0	$0	245 GPM @ 20.6% insoluble solids			
M-615	1	0	Equalization Basin	STRM0830	98,267	102,204	1.04	$350,000	1999	$350,000	0.79	$361,031	1.0	$361,031	$361,031	no less than 500,000 gal., above-ground bolted tank with cover, including foundations, pumps and controls	WM615	1,077.21	
M-616	1	0	Anaerobic Digestion System	STRM0830	98,267	102,204	1.04	$3,200,000	1999	$3,200,000	0.79	$3,300,852	1.0	$3,300,852	$3,300,852	500,000 gal., includes site work, foundations, reactors and ancillary equipment			
M-617	1	0	Aerobic Digestion System	STRM0830	98,267	102,204	1.04	$4,300,000	1999	$4,300,000	0.79	$4,435,520	1.0	$4,435,520	$4,435,520	four-350,000 gal. Sequencing Batch Reactors, 48,000 lbs/day of O2 transfer capability, de-nitrification facilities, aeration and mixing requires approximately 1,400 horsepower			
M-618	1	0	Pressure Sand Filters	STRM0830	98,267	102,204	1.04	$280,000	1999	$280,000	0.79	$288,825	1.0	$288,825	$288,825	400 ft2 of filtration surface area, includes the engineering and legal cost to acquire an NPDES permit			
P-630	1	1	Recycle Water Pump	STRM0602	179,446	84,120	0.47	$10,600	1997	$21,200	0.79	$11,652	2.8	$33,175	$11,882	370 gpm, 150ft head	WP630	14.75	
S-601	2	0	Beer Column Bottoms Centrifuge	CENTFLOW	404	300	0.74	$659,550	1998	$1,319,100	0.6	$1,103,371	1.2	$1,339,824	$1,116,520	requires 540gpm duty, 2 @ 300 gpm and 410 hp each	WS601	489.18	
T-630	1	0	Recycled Water Tank	STRM0602	179,446	84,120	0.47	$14,515	1998	$14,515	0.745	$8,254	1.7	$13,992	$8,353	7410 gal, 20 min. res., 2.5 psig, 9.5ft diam. x 14.25ft			
										weighted averages:	0.7609184		1.0					1,602.64
A600										Subtotal	$9,558,715	$9,542,206		$9,824,251	$9,556,310				
										2000lpd x .45 (current year cost with area weighted-average scale exponent applied)			1.3	$5,167,342	($4,656,910)	is installed cost savings			

Equi,)

																sizes not updated to reflect 25% increase, but costs and energy consumed are upd	
P-703	1	1	Sulfuric Acid Pump	STRM0710	1,647	1,912	1.16	$8,000	1997	$16,000	0.79	$18,001	2.8	$51,252	$18,357	215 gpm, 150ft head	WP703	
P-707	1	1	Antifoam Store Pump	STRM0417	227	105	0.46	$5,700	1997	$11,400	0.79	$6,193	2.8	$17,633	$6,315	0.5 gpm, 92 ft head	WP707	0.01
P-720	1	1	CSL Pump	STRM0735	2,039	859	0.42	$8,800	1997	$17,600	0.79	$8,889	2.8	$25,309	$9,065	182 gpm, 150ft head	WP720	0.15
T-703	1		Sulfuric Acid Storage Tank	STRM0710	1,647	1,912	1.16	$42,500	1997	$42,500	0.51	$45,860	1.8	$82,338	$46,767	20,000 gal, 240 hr supply, 90% wv, 12ft diam. x 24 ft, atmospheric		
T-707	1		Antifoam Storage Tank	STRM0417	227	303	1.33	$14,400	1997	$14,400	0.71	$17,663	1.7	$30,174	$18,012	12,000 gal, 27 day supply, 10.5ft diam. X 18.5ft		
T-720	1		CSL Storage Tank	STRM0735	2,039	859	0.42	$88,100	1997	$88,100	0.79	$44,495	1.7	$76,011	$45,375	30160 gal, 90% wv, 120 supply, 14.3ft diam. X 25 ft		
												area install factor	2.0					0.28
A700									Subtotal	$190,000		$141,101		$282,716	$143,891			
												2000tpd x .45 (current year cost with area weighted-average scale exponent applied)	1.5	$2,171,166	$1,888,451	is installed cost savings		
M-803	1	0	Boiler with Superheater	STRM0815 + 216	200,000	200,000	1.00	$1,590,000	1999	$1,590,000	0.7	$1,590,000	1.3	$2,067,000	$1,590,000	200,000 #/hr running @ 171,488 #/hr; with 40,000 #/hr 160o superheat; 132,000#/hr 390o sat. @ 205 psig	WM803	75.60
M-820	1	0	Hot process water softener system	STRM0811B	229,386	45,003	0.20	$1,383,300	1999	$1,383,300	0.6	$520,623	1.2	$624,748	$520,623	200 gpm		
M-830	1	0	Hydrazine Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agilator, 2 metering pumps	WM830	10.00
M-832	1	0	Ammonia Addition Pkg	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agilator, 2 metering pumps	WM832	10.00
M-834	1	0	Phosphate Addition Pkg	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agilator, 2 metering pumps	WM834	10.00
P-804	2	1	Condensate Pump	STRM811A	249,633	38,798	0.16	$7,100	1997	$21,300	0.79	$4,894	4.6	$22,958	$4,991	130 gpm, 150' head	WP804	9.21
P-824	2	1	Deaerator Feed Pump	STRM811A	196,000	38,798	0.20	$9,500	1997	$28,500	0.79	$7,927	8.3	$67,097	$8,084	180 gpm, 115' head	WP824	4.89
P-826	4	1	BFW Pump	STRM0813	207,310	80,536	0.39	$52,501	1998	$262,505	0.79	$124,377	1.4	$176,203	$125,859	310 gpm, 2740' head	WP826	400.99
P-828	1	1	Blowdown Pump	STRM0821	6,600	2,699	0.41	$5,100	1997	$10,200	0.79	$5,032	6.4	$32,842	$5,132	12 gpm, 150' head	WP828	0.42
P-830	1	1	Hydrazine Transfer Pump	STRM813A	229,386	80,536	0.35	$5,500	1997	$11,000	0.79	$4,811	6.4	$31,402	$4,907	3 gpm, 75' head	WP830	0.05
T-804	1	0	Condensate Collection Tank	STRM811A	229,386	38,798	0.17	$7,100	1997	$7,100	0.71	$2,011	3.3	$6,766	$2,050	200 gal, 1.5 min. res. time		
T-824	1	0	Condensate Surge Drum	STRM811A	150,000	38,798	0.26	$49,600	1997	$49,600	0.72	$18,734	5.0	$95,523	$19,105	2100 gal., 6' diam. X 10', 15 psig, res. time 11 min.		
T-826	1	0	Deaerator	STRM0813	267,000	80,536	0.30	$165,000	1998	$165,000	0.72	$69,616	6.5	$457,896	$70,446	3030 gal., 15 psig, 10 min. res.		
T-828	1	0	Blowdown Flash Drum	STRM0821	6,550	2,699	0.41	$9,200	1997	$9,200	0.72	$4,859	7.3	$36,168	$4,955	210 gal., 2.5' diam. X 6', 50 psig 17 min. res.		
T-830	1	0	Hydrazine Drum	STRM813A	229,386	80,536	0.35	$12,400	1997	$12,400	0.93	$4,685	7.0	$33,440	$4,777	138 gal, 3.75' x 1.25' diam., 10 psig		
										weighted averages:	0.6704429		1.5					521.16
A800									Subtotal	$3,607,105		$2,387,986		$3,684,612	$2,393,497			
												2000tpd x .45 (current year cost with area weighted-average scale exponent applied)	1.1	$23,046,972	$19,362,360	is installed cost savings		
M-902	1	0	Cooling Tower System	QCWCAPIT	41,100,000	12,955,985	0.32	$1,659,000	1998	$1,659,000	0.78	$674,161	1.2	$818,659	$682,216	40,000 gpm, 185.4MM BTU/hr	WM902	298.85
M-904	1	0	Plant Air Compressor	STRM0101	159,950	159,950	1.00	$60,100	1997	$60,100	0.34	$60,100	1.3	$79,675	$61,288	450 cfm, 125 psig outlet	WM904	186.40
M-908	1	0	Chilled Water Package	QCHLWCAP	5,040,000	2,268,000	0.45	$380,000	1997	$380,000	0.8	$200,610	1.2	$245,492	$204,577	1000 ton, 600kW	WM908	600.00
M-910	1	0	CIP System	STRM0914	63	28	0.45	$95,000	1995	$95,000	0.6	$58,837	1.2	$73,021	$60,851	designed by Delta-T, (est 0.2 kW)	WM910	0.20
P-902	1	1	Cooling Water Pumps	STRM0940	18,290,000	5,553,791	0.30	$332,300	1997	$664,600	0.79	$259,201	2.8	$737,993	$264,326	12300 gpm, 70ft head		
P-912	1	1	Make-up Water Pump	STRM0904	244,160	82,445	0.34	$10,800	1997	$21,600	0.79	$9,161	2.8	$26,084	$9,343	370 gpm, 75ft head	WP912	7.32
P-914	1	1	Process Water Circulating Pump	STRM0905	352,710	111,503	0.32	$11,100	1997	$22,200	0.79	$8,938	2.8	$25,449	$9,115	745 gpm, 75ft head	WP914	14.78
S-904	1	1	Instrument Air Dryer	STRM0101	159,950	71,977	0.45	$15,498	1999	$30,996	0.6	$19,197	1.3	$24,956	$19,197	134 scfm air dryer, -40F Dewpoint	WS601	4.91
T-904	1	0	Plant Air Receiver	STRM0101	159,950	53,316	0.33	$13,000	1997	$13,000	0.72	$5,894	1.7	$10,069	$6,011	300 gal., 200 psig		
T-914	1	0	Process Water Tank	STRM0905	352,710	111,503	0.32	$195,500	1997	$195,500	0.51	$108,663	1.8	$195,095	$110,811	234360 gal, 8hr res. time		
										weighted averages:	0.751991		1.57			400 gpm well pump, 500ft head	53.16	1,165.62
Area 900									Subtotal	$3,141,996		$1,404,783		$2,236,491	$1,427,733		Total kW	14,823
												2000tpd x .45 (current year cost with area weighted-average scale exponent applied)	1.3	$5,278,320	$3,041,829	is installed cost savings		

PLANT TOTAL:	**$57,333,793**	**$44,443,650**	**$62,741,793**
45% NREL TOTAL:			**$79,208,934**
SAVINGS: (do to much cheaper boiler and effect of separation of hydrolysis and fermentation)			**$16,467,141**
			20.79%

TUDY MODEL WITH REFRENCE MODEL CELLULASE PRODUCTION: CELLULASE PRODUCTION COST (as prorated based on fraction of liquor requ

CAPITAL INVESTMENT ASSUMPTIONS

1) Total capital investment

Civil Structural			$ 500,000	estimated
Area 100			$ 308,790	
Area 200			$ 751,332	
Area 300			$ -	
Area 307			$ -	
Area 400			$ 10,353,995	
Area 500			$ -	
Area 600			$ 430,086	
Area 700			$ 176,840	
Area 800			$ 64,163	
Area 900			$ 38,945	estimated
Fixed Capital			**$ 12,624,151**	
INDIRECTS	Prorateable	3.5%	$441,845	
	Process Development	2.0%	$252,483	
	Field Expense	8.0%	$1,009,932	
	Home Office Constr. Fee	12.0%	$1,514,898	
	Contingency	10.0%	$1,262,415	
	Start-up, Permits, Fees	3.0%	$378,725	
Working Capital per estimate			**$123,114**	1 mos Raw matls. + O&M
	Total Plant Cost		**$17,607,563**	
FEDERAL & STATE GRANTS		10%	($1,760,756)	
	Net Capital Investment		**$15,846,807**	

OPERATING COST ASSUMPTIONS **8,400** hr/yr

		Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Electricity		7,910	Kw-hr	$0.035	$277	$2,325,687
well water		0	kg	$0.000	$0	$0
Wastewater		2,977	kg	$0.00026	$1	$6,605
gypsum waste disposal	($33/ston)	57	kg	$0.0364	$2	$17,449
Total Utilities					$280	$2,349,741

Raw Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Corn Stover DRY (stm 101 less water)	1,884	kg	$0.016	$30.01	$252,113
Sulfuric Acid (stm 710)	43	kg	$0.100	$4.33	$36,403
Calcium Oxide (Lime stm 227)	17	kg	$0.293	$4.96	$41,650
Ammonia (stm 717)	73	kg	$0.162	$11.86	$99,586
Corn Steep Liquor (stm 735)	200	kg	$0.051	$10.21	$85,801
Nutrients	80	kg	$0.291	$23.31	$195,794
Cellulase Complex	0	kg	$3.000	$0.00	$0
Natural Gasoline (stm 701)	0	kg	$0.155	$0.00	$0
Diesel/Gasoline	4	kg	$0.155	$0.62	$5,198
WWT Chemicals	0.2	kg	$2.237	$0.52	$4,404
CW Chemicals	0.3	kg	$1.428	$0.42	$3,566
BFW Chemicals	1.3	kg	$0.226	$0.29	$2,435
Boiler Fuel (stm 813)	3	Mbtu	$2.500	$8.29	$69,637
Total Raw Materials				$95	$796,588

$per lb. calcs.

Processing Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Antifoam (Corn Oil)	105	kg	$0.304	$32	$267,948
Total Processing Materials				$32	$267,948

Operations and Maintenance Costs - DRY HANDLING (area 100)	each/day		wage	hr/day each	Total Cost /yr.
Supervisors	0.025	$	20.00	12	$2,200
Operators	0.100	$	16.00	12	$7,041
Laborers	0.402	$	16.00	12	$28,166
Maintenance	0.100	$	16.00	12	$7,041
Operations and Maintenance Costs - HYDROLYSIS/FERMENTATION (area 200, 300, 400, 500, 600)					
Supervisors	0.0	$	20.00	12	$2,200
Operators	0.2	$	16.00	8	$7,041
Laborers	0.1	$	16.00	8	$2,347
Technicians (Includes Lab.)	0.2	$	16.00	8	$7,041
Maintenance	0.2	$	16.00	8	$7,041
Operations and Maintenance Costs - Utilities (area 700, 800, 900)					
Supervisors	0.0	$	20.00	12	$1,100
Operators	0.2	$	16.00	8	$3,521
Laborers	0.1	$	16.00	8	$1,174
Technicians	0.1	$	16.00	8	$1,174
Maintenance	0.1	$	16.00	8	$2,347
Total Operations and maintenance labor costs					$79,437

Other Operations and Maintenance Costs			
Payroll Overhead	35% of operating labor	$	27,803
Maintenance Costs	2% of plant cost	$	252,483
Operating Supplies	0.25% of plant cost	$	31,560
Environmental	0.50% of plant cost	$	63,121
Local Taxes	1% of plant cost	$	126,242
Insurance	0.50% of plant cost	$	63,121
Overhead Costs	40% of labor, supervision,maint cost	$	31,775
Administrative Costs	1% of annual sales (less tax credits)	$	5,239
Distribution and Sales	0.5% of annual sales (less tax credits)	$	-
Total O&M Costs			$680,780

Operating Expenses:		
Utilities		2,349,741
Raw Materials		796,588
Processing Materials		267,948
Operation & Maintenance		680,780
Property Tax @	0.50% Book Value	79,234
Depreciation		1,056,454
Debt retierment		1,418,471
Total Operating Expense ($/yr)		**$6,649,217**

HIGH PLAINS YORK CELLULASE PRODUCTION WITH PURVISION TECHNOLOGY (as prorated based on fraction of liquor required)

CAPITAL INVESTMENT ASSUMPTIONS

1) Total capital investment

Civil Structural			$ 500,000	estimated
Area 100			$ 204,724	
Area 200			$ 381,629	
Area 300			$ -	
Area 307			$ -	
Area 400			$ 5,692,516	
Area 500			$ -	
Area 600			$ 313,763	
Area 700			$ 122,171	
Area 800			$ 31,259	
Area 900			$ 18,646	estimated
Fixed Capital			$ 7,264,708	
INDIRECTS	Prorateable	3.5%	$254,265	
	Process Development	2.0%	$145,294	
	Field Expense	8.0%	$581,177	
	Home Office Constr. Fee	12.0%	$871,765	
	Contingency	10.0%	$726,471	
	Start-up, Permits, Fees	3.0%	$217,941	
Working Capital per estimate			$84,188	1 mos Raw matls. + O&M
	Total Plant Cost		$10,145,809	
FEDERAL & STATE GRANTS		10%	($1,014,581)	
	Net Capital Investment		**$9,131,228**	

OPERATING COST ASSUMPTIONS 8,400 hr/yr

		Amount/hr	*Units*	*$/unit*	*Cost /hr.*	**Total Cost /yr**
Electricity		5,918	Kw-hr	$0.035	$207	$1,739,954
well water		0	kg	$0.000	$0	$0
Wastewater		2,232	kg	$0.00026	$1	$4,954
gypsum waste disposal	($33/ston)	43	kg	$0.0364	$2	$13,087
Total Utilities					$209	$1,757,995

Raw Material Costs

	Amount/hr	*Units*	*$/unit*	*Cost /hr.*	**Total Cost /yr**
Corn Stover DRY (stm 101 less water)	1,413	kg	$0.016	$22.51	$189,083
Sulfuric Acid (stm 710)	32	kg	$0.100	$3.25	$27,302
Calcium Oxide (Lime stm 227)	13	kg	$0.293	$3.72	$31,237
Ammonia (stm 717)	57	kg	$0.162	$9.30	$78,093
Corn Steep Liquor (stm 735)	151	kg	$0.051	$7.69	$64,629
Nutrients	60	kg	$0.291	$17.48	$146,846
Cellulase Complex	0	kg	$3.000	$0.00	$0
Natural Gasoline (stm 701)	0	kg	$0.155	$0.00	$0
Diesel/Gasoline	3	kg	$0.155	$0.46	$3,899
WWT Chemicals	0.0	kg	$2.237	$0.00	$0
CW Chemicals	0.0	kg	$1.428	$0.00	$0
BFW Chemicals	0.0	kg	$0.226	$0.00	$0
Boiler Fuel (stm 813)	2	Mbtu	$2.500	$6.22	$52,227
Total Raw Materials				$71	$593,315

Processing Material Costs

$per lb. calcs.

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Antifoam (Corn Oil)	79	kg	$0.441	$35	$291,248
Total Processing Materials				$35	$291,248

Operations and Maintenance Costs - DRY HANDLING (area 100)	each/day		wage	hr/day each	Total Cost /yr.
Supervisors	0.019	$	20.00	12	$1,650
Operators	0.075	$	16.00	12	$5,281
Laborers	0.301	$	16.00	12	$21,124
Maintenance	0.075	$	16.00	12	$5,281

Operations and Maintenance Costs - HYDROLYSIS/FERMENTATION (area 200, 300, 400, 500, 600)					
Supervisors	0.0	$	20.00	12	$1,650
Operators	0.1	$	16.00	8	$5,281
Laborers	0.0	$	16.00	8	$1,760
Technicians (Includes Lab.)	0.1	$	16.00	8	$5,281
Maintenance	0.1	$	16.00	8	$5,281

Operations and Maintenance Costs - Utilities (area 700, 800, 900)					
Supervisors	0.0	$	20.00	12	$825
Operators	0.1	$	16.00	8	$2,641
Laborers	0.0	$	16.00	8	$880
Technicians	0.0	$	16.00	8	$880
Maintenance	0.1	$	16.00	8	$1,760
Total Operations and maintenance labor costs					$59,577

Other Operations and Maintenance Costs			
Payroll Overhead	35% of operating labor	$	20,852
Maintenance Costs	2% of plant cost	$	145,294
Operating Supplies	0.25% of plant cost	$	18,162
Environmental	0.50% of plant cost	$	36,324
Local Taxes	1% of plant cost	$	72,647
Insurance	0.50% of plant cost	$	36,324
Overhead Costs	40% of labor, supervision,maint cost	$	23,831
Administrative Costs	1% of annual sales (less tax credits)	$	3,929
Distribution and Sales	0.5% of annual sales (less tax credits)	$	-
Total O&M Costs			$416,939

Operating Expenses:			
Utilities		1,757,995	2,349,741
Raw Materials		593,315	796,588
Processing Materials		291,248	267,948
Operation & Maintenance		416,939	680,780
Property Tax @	0.50% Book Value	45,656	79,234
Depreciation		608,749	1,056,454
Debt retierment		1,254,118	1,418,471
Total Operating Expense ($/yr)		**$4,968,020**	6,649,217

Savings With PureVision $ 1,681,197 / yr = 25.3%

based only on estimated enzyme production costs

ASSUMPTIONS

		NREL (.45)	3442
Fraction of pre-treated liquor required		5.024%	3.768%
Fraction of wastewater treated		4.38%	3.28%
Fraction of steam required		1.74%	1.31%
Fraction of ammonia required		15.77%	15.54%
Fraction of CSL required		22.03%	17.57%
ammonia storage tank estemated cost	$	100,000	

Comparison of On-site and Purchased Cellulase

Comparison of On-Site Cellulase Production via Pure Vision Technology and NREL Reference Model, to Purchase of Commercially Available Enzyme

CURRENT ASSUMPTION: ***BASED ON PUREVISION LABORATORY RESULTS OF COMPARISON***

	NREL*		Pure Vision		Purchased Cellulase ***
	M FPU required/yr**	difference	M FPU required/yr	difference	M FPU required/yr
	1,446,984	(50,708)	1,497,692	56,431	1,554,123
perating Projection:					
gal of fuel grade ethanol produced	$ 25,434,849	$ (311,275)	$ 25,746,124	$ 933,825	$ 26,679,948
Contract sale price per gallon	$ 1	$ -	$ 1	$ -	$ 1
Gross Annual Revenue	$ 27,978,334	$ (342,402)	$ 28,320,736	$ 1,027,207	$ 29,347,943
Small Ethanol Producer Tax Credit					
@ $ - per gallon	$ -		$ -		$ -
Total projected ethanol sales and credit	$ 27,978,334	$ (342,402)	$ 28,320,736	$ 1,027,207	$ 29,347,943
Gross Annual Co-Product Revenue	$ 328,822	$ -	$ 328,822	$ -	$ 328,822
Gross Sales and Credit	$ 28,307,156	$ (342,402)	$ 28,649,558	$ 1,027,207	$ 29,676,765
Operating Expenses:					
Utilities	$ 4,792,171	$ 567,400	$ 4,224,771	$ (1,803,557)	$ 2,421,214
Raw Materials	$ 12,843,241	$ 96,523	$ 12,746,718	$ 4,488,530,135	$ 4,501,276,853
Processing Materials	$ 267,948	$ 66,987	$ 200,961	$ (200,961)	$ -
Operation & Maintenance	$ 6,414,114	$ 70,428	$ 6,343,686	$ (505,618)	$ 5,838,069
Property Tax @ 0.50% Book Value	$ 486,736	$ 57,315	$ 429,421	$ (28,534)	$ 400,888
Depreciation	$ 6,038,644	$ 744,902	$ 5,293,743	$ (340,048)	$ 4,953,694
Total Operating Expense	$ 30,842,855	$ 1,603,554	$ 29,239,301	$ 4,485,651,417	$ 4,514,890,718
Net Operating Income	$ (2,535,699)	$ (1,945,956)	$ (589,742)	$(4,484,624,210)	$ (4,485,213,953)
				$ -	
Net Operating Cash Flow	$ 3,502,945	$ (1,201,055)	$ 4,704,000	$(4,484,964,258)	$ (4,480,260,258)

enzyme cost (cost of production calculated in "$per lb. calcs.") divided by lbs. per year flow rate from mass balance.	**$/lb**	$ 0.027	$ 0.020	$ 2.413
enzyme cost (cost of production calculated in "$per lb. calcs.") divided by million FPU per year required.	**$/MFPU**	**$ 4.60**	**$ 3.32**	**$ 2,753.93**

Annual Savings Using PureVision On-Site Enzyme Production	
OVER REFERENCE MODEL:	**$ 1,201,055**
OVER PURCHASED ENZYME:	**$ 4,484,964,258**

* 45% scale factor applied, SHCF

* * MFPU = million FPU

* * * Specialty Enzymes, Liquicell 2500, $2.00/lb, S.G. 1.100, 32 FPU/ml. [4, 7]

PLAINS YORK MODEL WITH PURCHASED CELLULASE FOR COMPARISON OF ON-SITE ENZYME PRODUCTION VS. PURCHASED

GAIN IN ETOH PRODUCTION POSSIBLE: 332 kg/hr A

10/27/99

ENZYMATIC HYDROLYSIS - PRO FORMA

lying Assumptions & Input Variables

URRENT SITUATION:

The Pro Forma models an Enzymatic Hydrolysis Ethanol plant using corn stover as the feed stock.

ETHANOL

The plant will convert corn stover to fuel grade ethanol utilizing enzymatic hydrolosis.

Corn stover feed rate of 71,977 kg/hr (str 101), produce estimated total output in

equivalent kilograms of fuel grade ETOH 9,483 kg/hr. = 79,659,865 kg / year (str 515)

gal./short ton= 76.8 3,176 gal/hr = 26,679,948 gal / year

gal./metric ton= 84.7

Increase to current York yearly production: 72%

The model assumes renewal of the ethanol excise tax credit of $.54 per gallon to the blender and **NOT** the small producer tax credit of $.10 per gallon through the year 2015 for a total ethanol value of

$1.10 per gallon or **$0.37** per kg and **$ 29,347,943 per year TOTAL Ethanol sales**

CARBON DIOXIDE

Currently, carbon dioxide from the High Plains York fermentations is sold to a CO_2 compression company.

Diverting the CO_2 (stm 550) from the stover plant into this stream for sale as opposed to the atmosphere provides

110,749 kg/hr = 930,294 ton / year with a value of $ 4.13 per metric ton

WITH THIS PROFORMA NO CO_2 IS SOLD. **CO_2 Value/year = $0**

LIGNIN

A Lignin co-product is produced and sold as combustion fuel material. A total amount of lignin in the stream (stm 601B) is

63,778 kg/hr = 535,734 metric ton / year is produced from the process.

The water in the lignin stream must be vaporized at a net BTU cost for the stream (stm 601B). Water vaporized is

43,969 kg/hr = 369,337 metric ton/year is vaporized at 1,100 BTU/lb loss = (107) MM BTU/hr

The remaining 19,809 kg/hr of stream 601B has 24,251 BTU/kg value = 480 MM BTU/hr

Total heating value from stream 601A is 374 MM BTU/hr

Gross Lignin Value/year = $7,848,926

Transport Cost = $7,848,926

Net Lignin Value = $0

METHANE

The digester produces 85% methane @ 353 kg/hr (stm 615) 44,332 BTU/kg CH4

Total heating value from Methane is 16 MM BTU/hr

methane is used in the DDG dryers and based on BTU value of $2.50 MM BTU

METHANE Value/year = $328,822

DIGESTER SLUDGE

The digester produces (stm 623) 0 kg/hr of sludge as fuel = 2,254 BTU/lb

based on 9,845 btu/lb biomass and 70% water in the sludge. = 4,969 BTU/kg

Total heating value from sludge is 0.00 MM BTU/hr

SLUDGE Value/year = $0

Sale of methane and lignin, based on BTU value is **$328,822 per year**

Total projected facility sales would be $29,676,765 per year

APITAL INVESTMENT ASSUMPTIONS

Total capital investment				
Civil Structural			(500,000)	
Area 100			6,146,434	
Area 200			14,955,166	
Area 300			4,028,307	
Area 307			3,714,334	
Area 400			651,440	
Area 500			7,515,486	
Area 600			9,824,251	
Area 700			234,910	
Area 800			3,684,612	
Area 900			2,236,491	
Fixed Capital			**$52,491,432**	
INDIRECTS	Prorateable	3.5%	$1,837,200	
	Process Development	2.0%	$1,049,829	
	Field Expense	8.0%	$4,199,315	
	Home Office Constr. Fee	12.0%	$6,298,972	
	Contingency	10.0%	$5,249,143	
	Start-up, Permits, Fees	3.0%	$1,574,743	
Working Capital per estimate			**$375,592,910**	1 mos Raw matls. + O&M
	Total Plant Cost		**$448,293,544**	
FEDERAL & STATE GRANTS		10%	($44,829,354)	
	Net Capital Investment		**$403,464,190**	

PERATING COST ASSUMPTIONS **8,400** hr/yr

Utilities (Rates based on **26,679,948** gal/yr produced)

	Amount/hr	*Units*	*$/unit*	*Cost /hr.*	**Total Cost /yr**
*Electricity	6,759	Kw-hr	$0.035	$237	$1,987,079
Well water	79,972	kg	$0.000	$0	$0
*Wastewater	39,119	kg	$0.00026	$10	$86,808
*Gypsum waste disposal	1,137	kg	$0.0364	$41	$347,327
		mTon	$1.103	$0	$0
Total Utilities				$288	$2,421,214

**** Quoted by High Plains***

Model Input (purchased)

Raw Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Corn Stover DRY (stm 101 less water)	37,500	kg	$0.680	$25,499.90	$214,199,143
*Sulfuric Acid (stm 710)	860	kg	$0.100	$86.26	$724,592
*Calcium Hydroxide (Lime stm 227)	337	kg	$0.293	$98.70	$829,039
*Ammonia (stm 717)	387	kg	$0.162	$62.77	$527,281
Corn Steep Liquor (stm 735)	708	kg	$0.051	$36.10	$303,280
Nutrients (stm 415)	0	kg	$0.291	$0.00	$0
Purchased Cellulase	211,123	lbs	$2.000	$422,246.70	$3,546,872,248
transport cost	750	miles	$3.000	$2250 /load	$733,071,990
*Natural Gasoline (stm 701)	391	kg	$0.155	$60.36	$506,988
*Rolling Stock Gasoline	79	kg	$0.155	$12.32	$103,470
*WWT Chemicals	5	kg	$0.000	$0.00	$0
*CW Chemicals	17	kg	$0.000	$0.00	$0
*BFW Chemicals	73.8	kg	$0.226	$16.65	$139,833
*Boiler Fuel (stm 813)	190	Mbtu	$2.500	$476.07	$3,998,989
Total Raw Materials				$448,596	$4,501,276,853

Quoted by High Plains

Processing Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
*Antifoam (Corn Oil)	0	kg	$0.304	$0	$0
Total Processing Materials				$0	$0

Quoted by High Plains

Operations and Maintenance Costs - DRY HANDLING (area 100)	each/day		wage	hr/day each	Total Cost /yr.
*Supervisors	0.5	$	20.00	12	$43,800
*Operators	2.0	$	16.00	12	$140,160
*Laborers	8.0	$	16.00	12	$560,640
*Maintenance	2.0	$	16.00	12	$140,160
Operations and Maintenance Costs - HYDROLYSIS/FERMENTATION (area 200, 300, 400, 500, 600)					
*Supervisors	1.0	$	20.00	12	$87,600
*Operators	8.0	$	16.00	8	$373,760
*Laborers	4.0	$	16.00	8	$186,880
*Technicians (Includes Lab.)	3.0	$	16.00	8	$140,160
*Maintenance	3.0	$	16.00	8	$140,160
Operations and Maintenance Costs - Utilities (area 700, 800, 900)					
*Supervisors	0.5	$	20.00	12	$21,900
*Operators	3.0	$	16.00	8	$70,080
*Laborers	1.0	$	16.00	8	$23,360
*Technicians	1.0	$	16.00	8	$23,360
*Maintenance	2.0	$	16.00	8	$46,720

Quoted by High Plains Standard HPY shifts are 12 hours.

Total Operations and maintenance labor costs $1,998,740

Other Operations and Maintenance Costs			
Payroll Overhead	35% of operating labor	$	699,559
Maintenance Costs	2% of plant cost	$	1,049,829
Operating Supplies	0.25% of plant cost	$	131,229
Environmental	0.50% of plant cost	$	262,457
Local Taxes	1% of plant cost	$	524,914
Insurance	0.50% of plant cost	$	262,457
Overhead Costs	40% of labor, supervision,maint cost	$	799,496
Administrative Costs	1% of annual sales (less tax credits)	$	109,388
Distribution and Sales	0.5% of annual sales (less tax credits)	$	-
Total O&M Costs			$5,838,069

THER MODEL ASSUMPTIONS

verage prevailing market price of fuel grade ETOH:		$0.37	per kg
ssumes renewal of the ethanol excise tax credit of $.54 per gallon		$ 1.10	per gallon
d the small producer tax credit of $.10 per gallon through the year 2007			
Value of CO_2 produced		$ 4.13	per metric ton
Price for Electricity		$ 0.035	per KWhr
Gas price per million BTU		$ 2.500	per MM BTU
		68%	Dry matter
orn Stover feedstock cost- **dry basis/short ton**	$ 14.45	$0.016	per kg
		$15.93	per metric ton
ant on-stream factor		0.959	
ant operating hours per year		8,400	
epreciable Life of Capital Equipment		15	years
verage annual commodity escalation rate:		3.0%	
verage annual cost escalation rate:		3.0%	

**** Quoted by High Plains***

There are no land acquisiton costs included.
There are no off site costs included (e.g. public road improvements, extensions of power, water, telephone services)
There is a source of qualified construction personnel within daily driving distance of the site
There exist adequate roads and rail roads to allow equipment delivery.
The costs for air and water permits are not included.
Soils are adequate for conventional foundation designs.

CALCULATIONS FOR REQUIRED AMOUNT OF PURCHASED CELLULASE LIQUICELL 2500

ASED ON PUREVISION LABORATORY RESULTS OF COMPARISON

High Grade Waste Paper Substrate

Soluble Charbohydrate % degraded in 18 hrs.			
Liquicell 2500	13%	87,059,020	ml/hr required for stover
PureVision Cellulase	82%	13,057,632	ml/hr required for stover
effectiveness multiple	6.43		

125	FPU/g protein	Liquicell 2500
731,295,772	liters/yr	Specialty
1.1000	S.G.	Enzymes
804,425,349	kg/yr	Inc.
193,062,084	gal/yr	
1,773,436,124	#/yr	
325,810	loads/yr	

1

cellulase storage tank
22,984 gal/hr
750,000 gal/vessel
33 vessel res. time (hr)
cellulase transfer pump
383 gpm

ASED ON PRODUCT SPECIFICATIONS PROVIDED BY SPECIALTY ENZYMES INC.

32	FPU/ml	Liquicell 2500
48,566,337	liters/yr	Specialty
1.1000	S.G.	Enzymes
53,422,971	kg/yr	Inc.
12,821,513	gal/yr	
117,776,282	#/yr	
21,637	loads/yr	

0

cellulase storage tank
14,021 gal/hr
750,000 gal/vessel
53 vessel res. time (hr)
cellulase transfer pump
234 gpm

ransport Calculations

10,000	lbs/axel		9.19	cellulase lb/gal
5	axels/truck		5,443	gal/truck
50,000	lbs/truck	$	**0.413**	**transport cost/lb**

stimated Equipment Costs for Reference Model Scaled Down 45% with P

hanges to Equipa automatically update these cells with the exception of those noted in red.

Equip No.	No. Req'd	No. Spare	Equip Name	Scaling Stream	Scaling Stream Flow (Kg/hr)	New Stream Flow	Size Ratio	Original Equip Cost (per unit)	Base Year	Total Original Equip Cost (Req'd & Spare)	Scaling Exponent	Scaled Cost in Base Year	Install Factor	Installed Cost	Scaled Uninstalled Cost in 1999$	Description	3442 WORK	
C-101	1	0	Bale conveyor	AREA0100	154	170	1.11	$15,000	1999	$15,000	0.6	$15,927	1.5	$24,551	$ 15,927	wire mesh conveyor 60" wide 20' long	WC101	11.93
C-102	1	0	Radial Stacker Conveyor	AREA0100	154	170	1.11	$159,830	1999	$159,830	0.6	$169,708	1.5	$261,604	$ 169,708	16 degree, 36" x 200' radial stacker, 750 ton/hr, 75 HP	WC102	44.74
C-103	1	0	Breaker Infeed Belt	AREA0100	154	170	1.11	$49,500	1999	$49,500	0.6	$52,559	1.5	$81,020	$ 52,559	84" x 35' rubber belt cleated infeed conveyor, 10 HP, TEFC drive motor with guard	WC103	5.97
C-104	1	0	1st Shredder Conveyor	AREA0100	154	170	1.11	$25,650	1999	$25,650	0.6	$27,235	1.5	$41,983	$ 27,235	60" wide x 25' long, 10 HP, TEFC drive with guard	WC104	5.97
C-105	1	0	1st Infeed Belt	AREA0100	154	170	1.11	$38,500	1999	$38,500	0.6	$40,879	1.5	$63,015	$ 40,879	60" wide x 30' long, 10 HP, TEFC drive with guard	WC105	11.93
C-106	1	0	2nd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.5	$48,285	$ 31,323	48" wide x 20' long, 7.5 HP, TEFC drive with guard	WC106	4.47
C-107	1	0	2nd Infeed Belt	AREA0100	154	170	1.11	$27,500	1999	$27,500	0.6	$29,200	1.5	$45,011	$ 29,200	48" wide x 30' long, 5 HP, TEFC drive with guard	WC107	2.98
C-108	1	0	3rd Shredder Conveyor	AREA0100	154	170	1.11	$29,500	1999	$29,500	0.6	$31,323	1.5	$48,285	$ 31,323	48" wide x 20' long, 10 HP, TEFC drive with guard	WC108	5.97
C-109	1	0	Feed Screw Conveyor	AREA0100	225,140	562,850	2.50	$31,700	1997	$31,700	0.6	$54,932	1.5	$86,351	$ 56,018	14" dia. 250' long	WC109	53.75
M-101	2	0	Truck Scale	AREA0100	96	72	0.75	$10,000	1999	$20,000	0.6	$16,829	1.5	$25,244	$ 16,829	96 deliveries /scale/12hr		
M-102	1	0	Receiving Pad	AREA0100	250,000	250,000	1.00	$2,083,500	1999	$2,083,500	0.6	$2,083,500	1.0	$2,083,500	$ 2,083,500	250,000 ft2 concrete pad, 9" thick with drainage		
M-103	6	1	Front End Loader	AREA0100	159,948	159,948	1.00	$156,000	1998	$1,092,000	0.6	$1,092,000	1.2	$ 1,326,016	$ 1,105,013	run on gasoline		
M-104	3	0	Bale Breaker	AREA0100	154	170	1.11	$250,000	1999	$750,000	0.6	$796,352	1.2	$955,622	$ 796,352	30 HP each	WM104	53.69
M-105	1	0	Primary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.2	$135,444	$ 112,870	250 HP, 1200 rpm, hammermill	WM105	149.14
M-106	1	0	Secondary Stover Shredder	AREA0100	154	170	1.11	$106,300	1999	$106,300	0.6	$112,870	1.5	$169,304	$ 112,870	250 HP, 1200 rpm, hammermill	WM106	149.14
M-107	1	0	Shred Bunker	AREA0100	600,000	600,000	1.00	$700,000	1999	$700,000	0.6	$700,000	1.0	$700,000	$ 700,000	200x100x30ft bunker with three walls, 3 days shred storage		
M-108	1	0	Storm Runoff Pond	AREA0100	1,747,767	1,747,767	1.00	$51,198	1998	$51,198	0.6	$51,198	1.0	$51,198	$ 51,808	200 x 150 x 8 ft, 240,000ft3		
										weighted averages:	0.6		1.1					499.68
A100										Subtotal		$5,315,978		$5,418,705	$6,146,434	$5,433,414		
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.3	$3,181,636	($2,964,798)	is installed cost savings		
												Cost Base Year =		$1,999				
A-201	1	0	In-line Sulfuric Acid Mixer	STRM0214	55,308	23,725	0.43	$1,900	1997	$1,900	0.48	$1,266	1.2	$1,585	$1,291	Static Mixer, 110 gpm total flow		
A-202	1	0	In-line NH3 Mixer	STRM0244	53,630	18,317	0.34	$1,500	1997	$1,500	0.48	$896	1.2	$1,122	$913	Static Mixer, 82 gpm total flow		
A-209	1	0	Overliming Tank Agitator	STRM0228	167,050	102,608	0.61	$19,800	1997	$19,800	0.51	$15,442	1.2	$19,345	$15,748	Top Mounted, 1800 rpm, 15 hp	WT209	8.39
A-224	1	0	Reacidification Tank Agitator	STRM0239	167,280	102,752	0.61	$65,200	1997	$65,200	0.51	$50,851	1.2	$63,702	$51,857	Top-Mounted, 1800 rpm, 54 hp	WT224	25.17
A-232	1	0	Reslurrying Tank Agitator	STRM0250	358,810	167,795	0.47	$36,000	1997	$36,000	0.51	$24,432	1.2	$30,606	$24,915	Top-Mounted, 1800 rpm, 25 hp	WT232	13.98
A-235	1	0	In-line Acidification Mixer	STRM0236	164,570	101,104	0.61	$2,600	1997	$2,600	0.48	$2,058	1.2	$2,578	$2,099	Static-Mixer, 440 gpm total flow		
C-201	1	0	Hydrolyzate Screw Conveyor	STRM0220	225,140	101,493	0.45	$59,400	1997	$59,400	0.78	$31,908	1.5	$50,158	$32,539	18" dia. 33' long, 3420 cfh max flow, 23 hp	WC201	13.72
C-202	1	0	Wash Solids Screw Conveyor	STRM0225	196,720	165,453	0.84	$23,700	1997	$23,700	1	$19,933	1.5	$31,334	$20,327	18" dia. 16' long, 3420 cfh max flow	WC202	16.70
C-225	1	0	Lime Solids Feeder			0		$3,900	1997	$3,900	1	$3,900	1.5	$6,131	$3,977	6" dia., 63 cfh, 3150 lb/hr max flow	WC225	0.15
H-200	1	0	Hydrolyzate Cooler	AREA0200	1,988	895	0.45	$45,000	1997	$45,000	0.51	$29,947	2.2	$66,543	$30,539	Fixed Tube Sheet, 900 sf, 20' dia. X 20' long		
H-201	1	1	Beer Column Feed Economizer	AREA0201	5,641	5,641	1.00	$139,350	1999	$278,700	0.68	$278,700	2.2	$607,278	$278,700	TEMA type AES shell and tube 5641 sf, 42" dia x 20' long		
M-202	1	0	Prehydrolysis Reactor	STRM0217	270,034	121,514	0.45	$12,461,841	1998	$12,461,841	0.78	$6,684,746	1.5	$10,146,612	$6,764,408	Vertical Screw, 10 min residence time	WM105	353.16
P-201	1	1	Sulfuric Acid Pump	STRM0710	1,647	414	0.25	$4,800	1997	$9,600	0.79	$3,228	2.8	$9,190	$3,291	2 gpm, 245 ft. head	WP201	0.40
P-209	1	1	Overlimed Hydrolyzate Pump	STRM0228	167,050	102,608	0.61	$10,700	1997	$21,400	0.79	$14,561	2.8	$41,458	$14,849	448 gpm, 150 ft. head	WP209	18.01
P-222	1	1	Filtered Hydrolyzate Pump	STRM0230	162,090	101,614	0.63	$10,800	1997	$21,600	0.79	$14,936	2.8	$42,526	$15,231	448 gpm, 150 ft head	WP222	17.83
P-223	1	0	Lime Unloading Blower	STRM0227	547	337	0.62	$47,600	1998	$47,600	0.5	$37,340	1.4	$52,898	$37,785	3341 cfm, 6 psi, 10,024 lb/hr	WP223	4.10
P-224	1	1	Hydrolysis Feed Pump	STRM0250	160,000	167,795	1.05	$64,934	1999	$129,868	0.6	$133,628	1.2	$160,354	$133,628	740 gpm, 240 ft head	WP224	119.31
P-225	1	1	ISEP Elution Pump	STRM0243	52,731	18,005	0.34	$7,900	1997	$15,800	0.79	$6,761	2.8	$19,249	$6,894	104 gpm, 150 ft head	WP225	3.92
P-226	1	1	ISEP Reload Pump	STRM0246	164,080	100,802	0.61	$8,700	1997	$17,400	0.79	$11,841	2.8	$33,714	$12,075	445 gpm, 150 ft head	WP226	17.92
P-227	1	1	ISEP Hydrolyzate Feed Pump	STRM0221	160,290	98,157	0.61	$10,700	1997	$21,400	0.79	$14,526	2.8	$41,359	$14,814	432 gpm, 150 ft head	WP227	16.81
P-239	1	1	Reacidified Liquor Pump	STRM0239	167,280	102,752	0.61	$10,800	1997	$21,600	0.79	$14,698	2.8	$41,847	$14,988	450 gpm, 100 ft head	WP239	12.09
S-202	3	0	Pre-IX Belt Filter Press	SOLD0220	57,000	57,000	1.00	$200,000	1998	$600,000	0.39	$600,000	1.4	$850,010	$607,150	Use 3 units for 45% of the flow as recommended by the vendor	WS202	19.69
S-221	1	0	ISEP	STRM0240	210,005	98,157	0.47	$2,058,000	1997	$2,058,000	0.33	$1,601,194	1.2	$1,959,422	$1,632,851	10 chambers (39" dia. X 84" high), 4" dia. Valve - Weak Base Resin	WS221	2.98
S-222	1	0	Hydroclone & Rotary Drum Filter	STRM0229	5,195	1,137	0.22	$165,000	1998	$165,000	0.39	$91,224	1.4	$129,235	$92,311	Hydrocyclone and Vacuum Filter for 453 gpm	WS222	11.93
S-227	1	0	LimeDust Vent Baghouse	STRM0227	548	337	0.61	$32,200	1997	$32,200	1	$19,778	1.5	$30,254	$20,169	3750 cfm, 625 sf, 6 cfm/sf		
T-201	1	0	Sulfuric Acid Storage	STRM0710	1,647	860	0.52	$5,760	1996	$5,760	0.71	$3,633	1.7	$6,283	$3,751	2000 gal., 24 hr. residence time, 90% wv, 5.5ft diam. X 11ft		
T-203	1	0	Blowdown Tank	STRM0217	270,300	121,514	0.45	$64,100	1997	$64,100	0.93	$30,475	1.7	$52,061	$31,078	7000 gal., 11' dia x 30' high, 10 min. res. time, 75% wv, 15 psig		
T-209	1	0	Overliming Tank	STRM0228	167,050	102,608	0.61	$71,000	1997	$71,000	0.71	$50,232	1.8	$90,186	$51,225	29850 gal., 16' dia. X 32' high, 1 hr. res. time, 90% wv, 15 psig		
T-220	1	0	Lime Storage Bin	STRM0227	548	548	1.00	$69,200	1997	$69,200	0.46	$69,200	1.8	$124,243	$70,568	4455 cf, 14' dia x 25' high, 1.5x rail car vol., atmospheric, 15 day storage max		
T-224	1	0	Reacidification Tank	STRM0239	102,752	102,752	1.00	$111,889	1999	$111,889	0.51	$111,889	1.8	$196,992	$111,889	120,000 gal., 28' dia x 28' high, 4 hr. res. time, 90% wv, atmospheric		
T-232	1	0	Slurrying Tank	STRM0250	358,810	167,795	0.47	$44,800	1997	$44,800	0.71	$26,117	1.8	$46,890	$26,633	11300 gal., 13' dia. X 25' high, 15 min. res. time, 90% wv		
0	0	0	0	0	0	0	0.00	$0	1999	$0	0	$0	-	$0	$0	0		
										weighted averages:	0.696961		1.5					676.27
A200										Subtotal		$16,527,758		$9,999,337	$14,955,166	$10,128,493		
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.5	$15,025,380	$70,213	is installed cost savings		

A-300	8	0	Fermentor Agitators	GALLONS	962,651	750,000	0.78	$19,676	1996	$157,408	0.51	$138,592	1.2	$175,799	$143,110	Side Mounted, 2 per vessel, 60 hp each, 0.15 hp/1000 gal	WT300	201.34
A-301	1	0	Seed Hold Tank Agitator	STRM0304	41,777	17,529	0.42	$12,551	1996	$12,551	0.51	$8,060	1.2	$10,223	$8,322	Top Mounted, 1800 rpm, 10 hp, 0.1 hp/1000 gal	WT301	5.59
A-304	2	0	4th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$11,700	1997	$23,400	0.51	$15,026	1.2	$18,824	$15,323	Top Mounted, 1800 rpm, 3 hp, 0.3 hp/1000 gal	WT304	3.36
A-305	2	0	5th Seed Vessel Agitator	STRM0304	41,777	17,529	0.42	$10,340	1996	$20,680	0.51	$13,280	1.2	$16,845	$13,713	Top Mounted, 1800 rpm, 9 hp, 0.1 hp/1000 gal	WT305	10.07
A-306	1	0	Beer Well Agitator	STRM0502	381,700	173,737	0.46	$10,100	1997	$10,100	0.51	$6,761	1.2	$8,469	$6,394	Top Mounted, 1800 rpm, 2 hp, 0.3 hp/1000 gal	WT306	1.12
F-300	4	0	Fermentors	GALLONS	750,000	750,000	1.00	$326,203	1999	$1,304,812	0.71	$1,304,812	1.8	$2,297,260	$1,304,812	750,000 gal. each, 2 day residence total, 90% wv, API, atmospheric, 50' f x 51'		
F-301	2	0	1st Fermentation Seed Fermentor	None		0	0.45	$14,700	1997	$29,400	0.93	$13,991	2.8	$39,948	$14,267	9 gal, jacketed, agitated, 1' dia., 1.5' high, 15 psig		
F-302	2	0	2nd Fermentation Seed Fermentor	None		0	0.45	$32,600	1997	$65,200	0.93	$31,027	2.8	$88,592	$31,640	90 gal., jacketed, agitated, 2' 3" dia., 3' high, 2.5 psig		
F-303	2	0	3rd Fermentation Seed Fermentor	None		0	0.45	$81,100	1997	$162,200	0.93	$77,186	2.8	$220,394	$78,712	900 gal., jacketed, agitated, 5' dia, 6.5' high, 2.5 psig		
F-304	2	0	4th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$39,500	1997	$79,000	0.93	$35,225	1.7	$60,174	$35,921	9000 gal., 9' dia x 19' high, atmospheric		
F-305	2	0	5th Fermentation Seed Fermentor	STRM0304	41,777	17,529	0.42	$147,245	1998	$294,490	0.51	$189,107	1.8	$336,910	$191,360	90000 gal., API, atmospheric 25'f x 25'		
H-300	4	1	Fermentation Cooler	QHX300EA	67,820	25,053	0.37	$4,000	1997	$20,000	0.78	$9,198	2.2	$20,436	$9,380	4 exchangers at 221 sf, U=300 BTU/hr sf F LMTD = 22.9°F plate and frame		
H-301	1	0	Fermentation Seed Hydrolyzate Cooler	AREA0301	773	318	0.41	$15,539	1998	$15,539	0.78	$7,778	2.2	$17,151	$7,871	348 sf, 300 BTU/hr sf F		
H-302	1	0	Fermentation Pre-Cooler	AREA0302	3,765	828	0.22	$25,409	1998	$25,409	0.78	$7,797	2.2	$17,193	$7,890	828 sf total, plate and frame		
H-304	1	0	4TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$3,300	1997	$3,300	0.83	$1,580	1.2	$1,934	$1,611	12 sf, 1" sch 40 pipe, 105 BTU/hr sf F		
H-305	1	0	5TH Seed Fermentor Coils	QSDF0301	38,339	15,789	0.41	$18,800	1997	$18,800	0.98	$7,881	1.2	$9,644	$8,037	138 sf, 2" sch 40 pipe, 92 BTU/hr sf F		
P-300	4	1	Fermentation Recirc /Transfer Pump	QHX300EA	67,737	55,505	0.82	$8,000	1997	$40,000	0.79	$34,177	2.8	$97,307	$34,852	844 gpm @ 150 ft sized based on heating rate	WP300	104.49
P-301	1	1	Fermentation Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$22,194	1998	$44,388	0.7	$24,168	1.4	$34,238	$24,456	280 gpm @ 150 ft head	WP301	5.95
P-302	2	0	Seed Transfer Pump	STRM0304	41,777	17,529	0.42	$54,088	1998	$108,176	0.7	$58,898	1.4	$83,440	$59,600	504 gpm total, 252 gpm each, 100 ft head	WP302	7.14
P-306	1	1	Beer Transfer Pump	STRM0502	381,701	173,737	0.46	$17,300	1997	$34,600	0.79	$18,579	2.8	$52,899	$18,947	790 gpm each, 171 ft head	WP306	34.47
T-301	1	0	Fermentation Seed Hold Tank	STRM0304	41,777	17,529	0.42	$161,593	1998	$161,593	0.51	$103,767	1.8	$184,870	$105,003	105000 gal., API atmospheric		
T-306	1	0	Beer Well	STRM0502	129,000	183,467	1.42	$111,889	1999	$111,889	0.51	$133,906	1.8	$235,756	$133,906	192,518 gal., 32' dia x 32' high, 4 hr. res. time, 95% wv, atmospheric		
										weighted averages:	0.6843466		1.8				373.53
A300									Subtotal	$2,742,935		$2,240,795		$4,028,307	$2,255,629			
										2000tpd x .45 (current year cost with area weighted average scale exponent applied)			1.3	$8,218,509	$4,190,202	is installed cost savings		
A-307	8	0	Enzymatic Hydrolysis Tank Agitators	STRM0302B	157,136	157,136	1.00	$19,676	1996	$157,408	0.51	$157,408	1.2	$199,666	$162,539	two side mounted 75 hp agitators / tank, 0.4hp/1000 gal.	WT307	251.67
H-307	12	0	Enzymatic Hydrolysis Tank Heater	STRM0302B	157,136	157,136	1.00	$15,000	1999	$180,000	0.78	$180,000	2.2	$392,214	$180,000	65 ft2 double pipe		
H-308	1	0	Pre-hydrolyzate cooler	STRM0302	145,536	145,536	1.00	$25,000	1999	$25,000	0.78	$25,000	2.2	$54,474	$25,000	481 ft2, parallel double pipe		
P-308	8	1	Hydrolyzer Bottoms Pump	STRM0302B	157,136	157,136	1.00	$121,690	1999	$1,095,210	0.6	$1,095,210	1.2	$1,314,252	$1,095,210	3000 GPM each Disc flow pumps, 245ft head	WP308	1,744.94
T-307	4	0	Enzymatic Hydrolysis Tank	STRM0302B	750,000	375,000	0.50	$326,203	1999	$1,304,812	0.6	$860,855	2.0	$1,753,728	$860,855	375,000 gallons, 24 hour residence time, 2 side mounted agitators cone bottom, concrete base, bottom outlet through the concrete, 30o cone bottom		
0	0	0	0	0	0	0	0.00	$0	1999	$0	0	$0	-	$0	$0	0		
										weighted averages:	0.6082295		1.6				1,996.61
Area 307									Subtotal	$2,762,430		$2,318,473		$3,714,334	$2,323,604			
												2000tpd x .45 (cu	-	$0	($3,714,334)	is installed cost savings		
																assumed to be adequate equipment for distribution and storage of purchased enzyme		
P-420	1	1	Cellulase Transfer Pump (assumed same as reference model recycle water pump)	STRM0602	179,446	84,120	0.47	$10,600	1997	$21,200	0.79	$11,652	2.8	$33,175	$11,882	370 gpm, 150ft head	WP630	14.75
A-401	2	0	Cellulase Storage Tank Agitators (assumed same as study model fermentor agitators)	GALLONS	962,651	750,000	0.78	$19,676	1996	$39,352	0.51	$34,648	1.2	$43,950	$35,777	Side Mounted, 2 per vessel, 60 hp each, 0.15 hp/1000 gal	WT401	67.11
T-708	1	0	Cellulase Storage Tank (assumed same as study model production fermenter)	GALLONS	750,000	750,000	1.00	$326,203	1999	$326,203	0.71	$326,203	1.8	$574,315	$326,203	750,000 gal., 34 hr supply by purchase projection method "A" or 42 hr supply by purchase projection method "B", API, atmospheric, 50' ϕ x 51'		
												area install factor	1.7					81.87
A400									Subtotal	$386,755		$372,503		$651,440	$373,863			
												2000tpd x .45	1.3	$7,057,277	$6,405,837			

D-501	1	0	Beer Column	DIAMD501	4	2.29	0.56	$636,976	1996	$636,976	0.78	$402,792	2.1	$873,434	$415,921	7'6" DIA, 32 ACTUAL TRAYS, NUTTER V-GRID TRAYS		
D-502	1	0	Rectification Column	S510S521	56,477	26,744	0.47	$525,800	1996	$525,800	0.78	$293,491	2.1	$636,421	$303,058	8' dia.(rect)., 4' dia. (strip) x 18" T.S., 60 act. Trays, 60% eff., Nutter V-Grid trays		
E-501	1	0	1st Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,676	1996	$435,676	0.68	$435,676	2.1	$944,742	$449,877	22278 sf each., 135 BTU/hr sf F		
E-502	1	0	2nd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.1	$944,685	$449,850	22278 sf., 170 BTU/hr sf F		
E-503	1	0	3rd Effect Evaporation	AREA0502	22,278	22,278	1.00	$435,650	1996	$435,650	0.68	$435,650	2.1	$944,685	$449,850	22278 sf each., 170 BTU/hr sf F		
H-501	1	0	Beer Column Reboiler	QRFD0501	-7,863,670	-3,723,722	0.47	$158,374	1996	$158,374	0.68	$95,263	2.2	$214,340	$98,368	Fixed TS, 6602 sf, 31" dia., 20' long, 178 BTU/hr sf F		
H-502	1	0	Rectification Column Reboiler	QRFD0502	-987,427	-467,581	0.47	$29,600	1997	$29,600	0.68	$17,805	2.2	$39,563	$18,157	Thermosyphon, 512 sf, 15" dia., 20' long, 130 BTU/hr sf F		
H-504	1	0	Beer Column Condenser	QCND0501	277,820	131,557	0.47	29,544	1996	$29,544	0.68	$17,771	2.2	$39,984	$18,350	Floating Head, 418 sf, 15" dia., 22' long, 92 BTU/hr sf F		
H-505	1	0	Rectification Column Condenser	QCND0502	4,905,410	2,322,883	0.47	86,174	1996	$86,174	0.68	$51,834	2.2	$116,626	$53,524	Fixed TS, 1969 sf, 29" dia, 20' long, 157 BTU/hr sf F		
H-512	1	1	Beer Column Feed Interchange	AREA0512	909	430	0.47	$19,040	1996	$38,080	0.68	$22,905	2.2	$51,537	$23,652	431 sf, 200 BTU/hr sf F		
H-517	1	1	Evaporator Condenser	QHET0517	6,764,222	3,203,095	0.47	$121,576	1996	$243,152	0.68	$146,257	2.2	$329,077	$151,024	Fixed TS, 3906 sf, 29" dia., 20' long, 220 BTU/hr sf F		
M-503	1	0	Molecular Sieve (9 pieces)	STRM0515	20,491	9,703	0.47	$2,700,000	1998	$2,700,000	0.7	$1,599,964	1.0	$1,619,030	$1,619,030	Superheater, twin mole sieve columns, product cooler, condenser, pumps, vacuum source.	WM503	55.00
P-501	1	1	Beer Column Bottoms Pump	P501FLOW	5,053	2,200	0.44	$42,300	1997	$84,600	0.79	$43,861	2.8	$124,881	$44,728	2200 gpm, 150 ft head	WP501	84.65
P-503	1	1	Beer Column Reflux Pump	QCND0501	277,820	131,557	0.47	$1,357	1998	$2,714	0.79	$1,504	2.8	$4,248	$1,522	6 gpm, 140 ft head	WP503	0.22
P-504	1	1	Rectification Column Bottoms Pump	STRM0516	31,507	15,530	0.49	$4,916	1998	$9,832	0.79	$5,622	2.8	$15,884	$5,689	76 gpm, 158 ft head	WP504	2.80
P-505	1	1	Rectification Column Reflux Pump	QCND0502	4,906,301	2,323,304	0.47	$4,782	1998	$9,564	0.79	$5,299	2.8	$14,970	$5,362	207 gpm, 110 ft head	WP505	5.14
P-511	2	1	1st Effect Pump	STRM0525	278,645	133,617	0.48	$19,700	1997	$59,100	0.79	$33,069	2.8	$94,155	$33,723	1137 gpm each, 110 ft head	WP511	67.89
P-512	1	1	2nd Effect Pump	STRM0528	91,111	45,390	0.50	$13,900	1997	$27,800	0.79	$16,032	2.8	$45,646	$16,349	599 gpm, 110 ft head	WP512	17.37
P-513	2	1	3rd Effect Pump	STRM0531	48,001	23,814	0.50	$8,000	1997	$24,000	0.79	$13,795	2.8	$39,276	$14,068	196 gpm each, 110 ft head	WP513	12.54
P-514	1	1	Evaporator Condensate Pump	STRM534A	140,220	69,285	0.49	$12,300	1997	$24,600	0.79	$14,095	2.8	$40,131	$14,374	293 gpm, 125 ft head	WP514	9.20
P-515	1	1	Scrubber Bottoms Pump	STRM0551	15,377	7,427	0.48	$2,793	1998	$5,586	0.79	$3,143	2.8	$8,881	$3,181	31 gpm, 104 ft head	WP515	0.84
P-517	1	1	Kill Tank Bottoms Pump	STRM0518	5,053	660	0.13	$42,300	1997	$84,600	0.79	$48,242	2.8	$48,242	$17,279	660gpm, 72 ft head	WP517	12.19
T-503	1	0	Beer Column Reflux Drum	QCND0501	277,820	131,557	0.47	$11,900	1997	$11,900	0.93	$5,938	1.7	$10,144	$6,055	164 gal, 15 min res. Time, 50% wv, 2'6" dia., 5' long, 25 psig		
T-505	1	0	Rectification Column Reflux Drum	QCND0502	4,906,301	2,323,304	0.47	$45,600	1997	$45,600	0.72	$26,621	1.7	$45,476	$27,147	6225 gal, 15 min res time, 50% wv, 7' dia., 22' long, 25 psig		
T-512	1	0	Vent Scrubber	STRM0523	18,523	9,788	0.53	$99,000	1998	$99,000	0.78	$60,197	1.7	$102,043	$60,915	5' dia x 25' high, 4 stages, plastic Jaeger Tri-Packing		
T-513	1	0	Kill Tank	STRM0518	149,897	149,897	1.00	$99,920	1999	$99,920	0.78	$99,920	1.7	$167,384	$99,920	18 psig, 30 min. res. time		
										weighted averages:	0.7164992		1.7				267.85
A500										Subtotal		$6,343,492		$4,301,097		$7,515,486	$4,400,972	
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.7	$6,765,614		($749,872)	is installed cost savings	
C-601	1	0	Lignin conveyor	STRM0601B	225,140	225,140	1.00	$31,700	1997	$31,700	0.60	$31,700	1.5	$49,832	$32,327	14" dia. 100' long	WC109	21.50
M-613	1	0	Syrup Sprayer	STRM0531	22,372	22,372	1.00	$1,000	1999	$1,000	0.30	$1,000	1.2	$1,200	$1,000	100 GPM syrup sprayer		
M-614	1	0	Lignin Loadout	STRM0601A	63,778	0	0.00	$41,200	1999	$41,200	0.30	$0	1.0	$0	$0	245 GPM @ 20.6% insoluble solids		
M-615	1	0	Equalization Basin	STRM0830	98,267	102,204	1.04	$350,000	1999	$350,000	0.79	$361,031	1.0	$361,031	$361,031	no less than 500,000 gal., above-ground bolted tank with cover, including foundations, pumps and controls	WM615	1,077.21
M-616	1	0	Anaerobic Digestion System	STRM0830	98,267	102,204	1.04	$3,200,000	1999	$3,200,000	0.79	$3,300,852	1.0	$3,300,852	$3,300,852	500,000 gal., includes site work, foundations, reactors and ancillary equipment		
M-617	1	0	Aerobic Digestion System	STRM0830	98,267	102,204	1.04	$4,300,000	1999	$4,300,000	0.79	$4,435,520	1.0	$4,435,520	$4,435,520	four-350,000 gal. Sequencing Batch Reactors, 48,000 lbs/day of O2 transfer capability, de-nitrification facilities, aeration and mixing requires approximately 1,400 horsepower		
M-618	1	0	Pressure Sand Filters	STRM0830	98,267	102,204	1.04	$260,000	1999	$260,000	0.79	$288,825	1.0	$288,825	$288,825	400 ft2 of filtration surface area, includes the engineering and legal cost to acquire an NPDES permit		
P-630	1	1	Recycle Water Pump	STRM0602	179,446	84,120	0.47	$10,600	1997	$21,200	0.79	$11,652	2.8	$33,175	$11,862	370 gpm, 150ft head	WP630	14.75
S-601	2	0	Beer Column Bottoms Centrifuge	CENTFLOW	404	300	0.74	$659,550	1998	$1,319,100	0.60	$1,103,371	1.2	$1,339,824	$1,116,520	requires 540gpm duty, 2 @ 300 gpm and 410 hp each	WS601	489.18
T-630	1	0	Recycled Water Tank	STRM0602	179,446	84,120	0.47	$14,515	1998	$14,515	0.75	$8,254	1.7	$13,992	$8,353	7410 gal, 20 min. res., 2.5 psig, 9.5ft diam. x 14.25ft		
										weighted averages:	0.7609184		1.0				1,602.64
A600										Subtotal		$9,558,715		$9,542,206		$9,824,251	$9,556,310	
										2000tpd x .45 (current year cost with area weighted-average scale exponent applied)			1.3	$5,167,342		($4,656,910)	is installed cost savings	

P-703	1	1	Sulfuric Acid Pump	STRM0710	1,647	1,912	1.16	$8,000	1997	$16,000	0.79	$18,001	2.8	$51,253	$18,357	215 gpm, 150ft head	WP703	0.09
P-720	1	1	CSL Pump	STRM0735	2,039	859	0.42	$8,800	1997	$17,600	0.79	$8,889	2.8	$25,308	$9,065	182 gpm, 150ft head	WP720	0.15
T-703	1	0	Sulfuric Acid Storage Tank	STRM0710	1,647	1,912	1.16	$42,500	1997	$42,500	0.51	$45,860	1.8	$82,338	$46,767	20,000 gal, 240 hr supply, 90% wv, 12ft diam. x 24 ft, atmospheric		
T-720	1	0	CSL Storage Tank	STRM0735	2,039	859	0.42	$88,100	1997	$88,100	0.79	$44,495	1.7	$76,011	$45,375	30160 gal, 90% wv, 120 supply, 14.3ft diam. X 25 ft		
												area install factor		2.0				0.24
										$164,200				$234,910	$119,563			
									Subtotal			2000tpd x .45		$819,339	$584,429			
M-803	1	0	Boiler with Superheater	M0815 + 216	200,000	200,000	1	1,590,000	1999	$1,590,000	0.7	$1,590,000	1.3	$2,067,000	$1,590,000	200,000 #/hr running @ 171,488 #/hr; with 40,000 #/hr 160o superheat; 132,000#/hr 390o sat. @ 205 psig	WM803	75.60
M-820	1	0	Hot process water softener system	STRM0811B	229,386	45,003	0.20	$1,383,300	1999	$1,383,300	0.6	$520,623	1.2	$624,748	$520,623	200 gpm		
M-830	1	0	Hydrazine Addition Pkg.	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps	WM830	10.00
M-832	1	0	Ammonia Addition Pkg	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps	WM832	10.00
M-834	1	0	Phosphate Addition Pkg	STRM813A	229,386	80,536	0.35	$19,000	1994	$19,000	0.6	$10,139	1.0	$10,857	$10,857	75 gal tank, agitator, 2 metering pumps	WM834	10.00
P-804	2	1	Condensate Pump	STRM811A	249,633	38,798	0.16	$7,100	1997	$21,300	0.79	$4,894	4.6	$22,958	$4,991	130 gpm, 150' head	WP804	9.21
P-824	2	1	Deaerator Feed Pump	STRM811A	196,000	38,798	0.20	$9,500	1997	$28,500	0.79	$7,927	8.3	$67,097	$8,084	180 gpm, 115' head	WP824	4.89
P-826	4	1	BFW Pump	STRM0813	207,310	80,536	0	$52,501	1998	$262,505	0.79	$124,377	1.4	$176,203	$125,859	310 gpm, 2740' head	WP826	400.99
P-828	1	1	Blowdown Pump	STRM0821	6,600	2,699	0	$5,100	1997	$10,200	0.79	$5,032	6.4	$32,842	$5,132	12 gpm, 150' head	WP828	0.42
P-830	1	1	Hydrazine Transfer Pump	STRM813A	229,386	80,536	0	5,500	1997	$11,000	0.79	$4,811	6.4	$31,402	$4,907	3 gpm, 75' head	WP830	0.05
T-804	1	0	Condensate Collection Tank	STRM811A	229,386	38,798	0	7,100	1997	$7,100	0.71	$2,011	3.3	$6,766	$2,050	200 gal, 1.5 min. res. time		
T-824	1	0	Condensate Surge Drum	STRM811A	150,000	38,798	0.26	$49,600	1997	$49,600	0.72	$18,734	5.0	$95,523	$19,105	2100 gal., 6' diam. X 10', 15 psig, res. time 11 min.		
T-826	1	0	Deaerator	STRM0813	267,000	80,536	0.30	$165,000	1998	$165,000	0.72	$69,616	6.5	$457,896	$70,446	3030 gal., 15 psig, 10 min. res.		
T-828	1	0	Blowdown Flash Drum	STRM0821	6,550	2,699	0.41	$9,200	1997	$9,200	0.72	$4,859	7.3	$36,168	$4,955	210 gal., 2.5' diam. X 6', 50 psig 17 min. res.		
T-830	1	0	Hydrazine Drum	STRM813A	229,386	80,536	0.35	$12,400	1997	$12,400	0.93	$4,685	7.0	$33,440	$4,777	138 gal, 3.75' x 1.25' diam., 10 psig		
										weighted averages:	0.6704429		1.5					521.16
A800									Subtotal	$3,607,105		$2,387,986		$3,684,612	$2,393,497			
									2000tpd x .45 (current year cost with area weighted-average scale exponent applied)				1.1	$23,046,972	$19,362,360	is installed cost savings		
M-902	1	0	Cooling Tower System	QCWCAPIT	41,100,000	12,955,985	0.32	$1,659,000	1998	$1,659,000	0.78	$674,181	1.2	$818,659	$682,216	40,000 gpm, 185.4MM BTU/hr	WM902	298.85
M-904	1	0	Plant Air Compressor	STRM0101	159,950	159,950	1.00	$60,100	1997	$60,100	0.34	$60,100	1.3	$79,675	$61,288	450 cfm, 125 psig outlet	WM904	186.40
M-908	1	0	Chilled Water Package	QCHLWCAP	5,040,000	2,268,000	0.45	$380,000	1997	$380,000	0.8	$200,610	1.2	$245,492	$204,577	1000 ton, 600kW	WM908	600.00
M-910	1	0	CIP System	STRM0914	63	28	0.45	$95,000	1995	$95,000	0.6	$58,837	1.2	$73,021	$60,851	designed by Delta-T, (est 0.2 kW)	WM910	0.20
P-902	1	1	Cooling Water Pumps	STRM0940	18,290,000	5,553,791	0.30	$332,300	1997	$664,600	0.79	$259,201	2.8	$737,993	$264,326	12300 gpm, 70ft head		
P-912	1	1	Make-up Water Pump	STRM0904	244,160	82,445	0.34	$10,800	1997	$21,600	0.79	$9,161	2.8	$26,084	$9,343	370 gpm, 75ft head	WP912	7.32
P-914	1	1	Process Water Circulating Pump	STRM0905	352,710	111,503	0.32	$11,100	1997	$22,200	0.79	$8,938	2.8	$25,449	$9,115	745 gpm, 75ft head	WP914	14.78
S-904	1	1	Instrument Air Dryer	STRM0101	159,950	71,977	0	$15,498	1999	$30,996	0.6	$19,197	1.3	$24,956	$19,197	134 scfm air dryer, -40F Dewpoint	WS601	4.91
T-904	1	0	Plant Air Receiver	STRM0101	159,950	53,316	0	$13,000	1997	$13,000	0.72	$5,894	1.7	$10,069	$6,011	300 gal., 200 psig		
T-914	1	0	Process Water Tank	STRM0905	352,710	111,503	0	195,500	1997	$195,500	0.51	$108,663	1.8	$195,095	$110,811	234360 gal, 8hr res. time		
Area 900									Subtotal	$3,141,996		$1,404,783		$2,236,491	$1,427,733			1,112.46
									2000tpd x .45 (current year cost with area weighted-average scale exponent applied)				1.3	$5,278,320	$3,041,829	is installed cost savings	Total kW	6,759

3442 PLANT TOTAL:	$50,551,344	$37,985,888	$62,991,432
45% NREL TOTAL:			$74,640,389
SAVINGS:			$21,568,856
			28.93%

Comparison of On-Site Cellulase Production via Pure Vision Technology and NREL Reference Model, to Purchase of Commercially Available Enzyme

CURRENT ASSUMPTION: ***BASED ON PRODUCT SPECIFICATIONS PROVIDED BY SPECIALTY ENZYMES INC.***

	NREL*		Pure Vision		Purchased Cellulase ***
	M FPU required/yr**	difference	M FPU required/yr	difference	M FPU required/yr
	1,446,984	(50,708)	1,497,692	56,431	1,554,123
Operating Projection:					
gal of fuel grade ethanol produced	$ 25,434,849	$ (311,275)	$ 25,746,124	$ 933,825	$ 26,679,948
Contract sale price per gallon	$ 1	$ -	$ 1	$ -	$ 1
Gross Annual Revenue	$ 27,978,334	$ (342,402)	$ 28,320,736	$ 1,027,207	$ 29,347,943
Small Ethanol Producer Tax Credit					
@ $ - per gallon	$ -		$ -		$ -
Total projected ethanol sales and credit	$ 27,978,334	$ (342,402)	$ 28,320,736	$ 1,027,207	$ 29,347,943
Gross Annual Co-Product Revenue	$ 328,822	$ -	$ 328,822	$ -	$ 328,822
Gross Sales and Credit	$ 28,307,156	$ (342,402)	$ 28,649,558	$ 1,027,207	$ 29,676,765
Operating Expenses:					
Utilities	$ 4,792,171	$ 567,400	$ 4,224,771	$ (1,803,557)	$ 2,421,214
Raw Materials	$ 12,843,241	$ 96,523	$ 12,746,718	$ 492,822,759	$ 505,569,478
Processing Materials	$ 267,948	$ 66,987	$ 200,961	$ (200,961)	$ -
Operation & Maintenance	$ 6,414,114	$ 70,428	$ 6,343,686	$ (505,618)	$ 5,838,069
Property Tax @ 0.50% Book Value	$ 486,736	$ 57,315	$ 429,421	$ (28,534)	$ 400,888
Depreciation	$ 6,038,644	$ 744,902	$ 5,293,743	$ (340,048)	$ 4,953,694
Total Operating Expense	$ 30,842,855	$ 1,603,554	$ 29,239,301	$ 489,944,041	$ 519,183,342
Net Operating Income	$ (2,535,699)	$ (1,945,956)	$ (589,742)	$ (488,916,834)	$ (489,506,577)
				$ -	
Net Operating Cash Flow	$ 3,502,945	$ (1,201,055)	$ 4,704,000	$ (489,256,883)	$ (484,552,883)

enzyme cost (cost of production calculated in "$per lb. calcs.") divided by lbs. per year flow rate from mass balance.	$/lb	$ 0.027	$ 0.020	$ 2.413
enzyme cost (cost of production calculated in "$per lb. calcs.") divided by million FPU per year required.	$/MFPU	**$ 4.60**	**$ 3.32**	**$ 182.89**

Annual Savings Using PureVision On-Site Enzyme Production	
OVER REFERENCE MODEL:	$ 1,201,055
OVER PURCHASED ENZYME:	$ 489,256,883

* 45% scale factor applied, SHCF

** MFPU = million FPU

*** Specialty Enzymes, Liquicell 2500, $2.00/lb, S.G. 1.100, 32 FPU/ml. [14, 7]

PLAINS YORK MODEL WITH PURCHASED CELLULASE FOR COMPARISON OF ON-SITE ENZYME PRODUCTION VS. PURCHASED

GAIN IN ETOH PRODUCTION POSSIBLE: 332 kg/hr A

10/27/99

. ENZYMATIC HYDROLYSIS - PRO FORMA

lying Assumptions & Input Variables

URRENT SITUATION:

The Pro Forma models an Enzymatic Hydrolysis Ethanol plant using corn stover as the feed stock.

ETHANOL

The plant will convert corn stover to fuel grade ethanol utilizing enzymatic hydrolosis.

Corn stover feed rate of 71,977 kg/hr (str 101), produce estimated total output in

equivalent kilograms of fuel grade ETOH 9,483 kg/hr. = 79,659,865 kg / year (str 515)

gal./short ton= 76.8 3,176 gal/hr = 26,679,948 gal / year

gal./metric ton= 84.7

Increase to current York yearly production: 72%

The model assumes renewal of the ethanol excise tax credit of $.54 per gallon to the blender and **NOT** the small producer tax credit of $.10 per gallon through the year 2015 for a total ethanol value of

$1.10 per gallon or $0.37 per kg and **$ 29,347,943 per year TOTAL Ethanol sales**

CARBON DIOXIDE

Currently, carbon dioxide from the High Plains York fermentations is sold to a CO_2 compression company.

Diverting the CO_2 (stm 550) from the stover plant into this stream for sale as opposed to the atmosphere provides

110,749 kg/hr = 930,294 ton / year with a value of $ 4.13 per metric ton

WITH THIS PROFORMA NO CO_2 IS SOLD. **CO_2 Value/year = $0**

LIGNIN

A Lignin co-product is produced and sold as combustion fuel material. A total amount of lignin in the stream (stm 601B) is

63,778 kg/hr = 535,734 metric ton / year is produced from the process.

The water in the lignin stream must be vaporized at a net BTU cost for the stream (stm 601B). Water vaporized is

43,969 kg/hr = 369,337 metric ton/year is vaporized at 1,100 BTU/lb loss = (107) MM BTU/hr

The remaining 19,809 kg/hr of stream 601B has 24,251 BTU/kg value = 480 MM BTU/hr

Total heating value from stream 601A is 374 MM BTU/hr

Gross Lignin Value/year = $7,848,926

Transport Cost = $7,848,926

Net Lignin Value = $0

METHANE

The digester produces 85% methane @ 353 kg/hr (stm 615) 44,332 BTU/kg CH4

Total heating value from Methane is 16 MM BTU/hr

methane is used in the DDG dryers and based on BTU value of $2.50 MM BTU

METHANE Value/year = $328,822

DIGESTER SLUDGE

The digester produces (stm 623) 0 kg/hr of sludge as fuel = 2,254 BTU/lb

based on 9,845 btu/lb biomass and 70% water in the sludge. = 4,969 BTU/kg

Total heating value from sludge is 0.00 MM BTU/hr

SLUDGE Value/year = $0

Sale of methane and lignin, based on BTU value is **$328,822 per year**

Total projected facility sales would be $29,676,765 per year

APITAL INVESTMENT ASSUMPTIONS

Total capital investment				
Civil Structural			(500,000)	
Area 100			6,146,434	
Area 200			14,955,166	
Area 300			4,028,307	
Area 307			3,714,334	
Area 400			651,440	
Area 500			7,515,486	
Area 600			9,824,251	
Area 700			234,910	
Area 800			3,684,612	
Area 900			2,236,491	
Fixed Capital			**$52,491,432**	
INDIRECTS	Prorateable	3.5%	$1,837,200	
	Process Development	2.0%	$1,049,829	
	Field Expense	8.0%	$4,199,315	
	Home Office Constr. Fee	12.0%	$6,298,972	
	Contingency	10.0%	$5,249,143	
	Start-up, Permits, Fees	3.0%	$1,574,743	
Working Capital per estimate			**$42,617,296**	1 mos Raw matls. + O&M
	Total Plant Cost		**$115,317,929**	
FEDERAL & STATE GRANTS		10%	($11,531,793)	
	Net Capital Investment		**$103,786,136**	

PERATING COST ASSUMPTIONS **8,400** hr/yr

Utilities (Rates based on **26,679,948** gal/yr produced)

	Amount/hr	*Units*	*$/unit*	*Cost /hr.*	**Total Cost /yr**
*Electricity	6,759	Kw-hr	$0.035	$237	$1,987,079
Well water	79,972	kg	$0.000	$0	$0
*Wastewater	39,119	kg	$0.00026	$10	$86,808
*Gypsum waste disposal	1,137	kg	$0.0364	$41	$347,327
		mTon	$1.103	$0	$0
Total Utilities				$288	$2,421,214

Quoted by High Plains

Model Input (purchased)

Raw Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
Corn Stover DRY (stm 101 less water)	37,500	kg	$0.680	$25,499.90	$214,199,143
*Sulfuric Acid (stm 710)	860	kg	$0.100	$86.26	$724,592
*Calcium Hydroxide (Lime stm 227)	337	kg	$0.293	$98.70	$829,039
*Ammonia (stm 717)	387	kg	$0.162	$62.77	$527,281
Corn Steep Liquor (stm 735)	708	kg	$0.051	$36.10	$303,280
Nutrients (stm 415)	0	kg	$0.291	$0.00	$0
Purchased Cellulase	14,021	lbs	$2.000	$28,041.97	$235,552,564
transport cost	750	miles	$3.000	$2250 /load	$48,684,298
*Natural Gasoline (stm 701)	391	kg	$0.155	$60.36	$506,988
*Rolling Stock Gasoline	79	kg	$0.155	$12.32	$103,470
*WWT Chemicals	5	kg	$0.000	$0.00	$0
*CW Chemicals	17	kg	$0.000	$0.00	$0
*BFW Chemicals	73.8	kg	$0.226	$16.65	$139,833
*Boiler Fuel (stm 813)	190	Mbtu	$2.500	$476.07	$3,998,989
Total Raw Materials				$54,391	$505,569,478

Quoted by High Plains

Processing Material Costs

	Amount/hr	Units	$/unit	Cost /hr.	Total Cost /yr
*Antifoam (Corn Oil)	0	kg	$0.304	$0	$0
Total Processing Materials				$0	$0

Quoted by High Plains

Operations and Maintenance Costs - DRY HANDLING (area 100)	each/day		wage	hr/day each	Total Cost /yr.
*Supervisors	0.5	$	20.00	12	$43,800
*Operators	2.0	$	16.00	12	$140,160
*Laborers	8.0	$	16.00	12	$560,640
*Maintenance	2.0	$	16.00	12	$140,160
Operations and Maintenance Costs - HYDROLYSIS/FERMENTATION (area 200, 300, 400, 500, 600)					
*Supervisors	1.0	$	20.00	12	$87,600
*Operators	8.0	$	16.00	8	$373,760
*Laborers	4.0	$	16.00	8	$186,880
*Technicians (Includes Lab.)	3.0	$	16.00	8	$140,160
*Maintenance	3.0	$	16.00	8	$140,160
Operations and Maintenance Costs - Utilities (area 700, 800, 900)					
*Supervisors	0.5	$	20.00	12	$21,900
*Operators	3.0	$	16.00	8	$70,080
*Laborers	1.0	$	16.00	8	$23,360
*Technicians	1.0	$	16.00	8	$23,360
*Maintenance	2.0	$	16.00	8	$46,720

Quoted by High Plains Standard HPY shifts are 12 hours.

Total Operations and maintenance labor costs $1,998,740

Other Operations and Maintenance Costs			
Payroll Overhead	35% of operating labor	$	699,559
Maintenance Costs	2% of plant cost	$	1,049,829
Operating Supplies	0.25% of plant cost	$	131,229
Environmental	0.50% of plant cost	$	262,457
Local Taxes	1% of plant cost	$	524,914
Insurance	0.50% of plant cost	$	262,457
Overhead Costs	40% of labor, supervision,maint cost	$	799,496
Administrative Costs	1% of annual sales (less tax credits)	$	109,388
Distribution and Sales	0.5% of annual sales (less tax credits)	$	-
Total O&M Costs			$5,838,069

THER MODEL ASSUMPTIONS

verage prevailing market price of fuel grade ETOH:		$0.37	per kg
ssumes renewal of the ethanol excise tax credit of $.54 per gallon		$ 1.10	per gallon
nd the small producer tax credit of $.10 per gallon through the year 2007			
Value of CO_2 produced		$ 4.13	per metric ton
Price for Electricity		$ 0.035	per KWhr
Gas price per million BTU		$ 2.500	per MM BTU
		68%	Dry matter
orn Stover feedstock cost- **dry basis/short ton**	$ 14.45	$0.016	per kg
		$15.93	per metric ton
ant on-stream factor		0.959	
ant operating hours per year		8,400	
epreciable Life of Capital Equipment		15	years
verage annual commodity escalation rate:		3.0%	
verage annual cost escalation rate:		3.0%	

Quoted by High Plains

There are no land acquisiton costs included.
There are no off site costs included (e.g. public road improvements, extensions of power, water, telephone services)
There is a source of qualified construction personnel within daily driving distance of the site
There exist adequate roads and rail roads to allow equipment delivery.
The costs for air and water permits are not included.
Soils are adequate for conventional foundation designs.

CALCULATIONS FOR REQUIRED AMOUNT OF PURCHASED CELLULASE LIQUICELL 2500

ASED ON PUREVISION LABORATORY RESULTS OF COMPARISON

High Grade Waste Paper Substrate

Soluble Charbohydrate % degraded in 18 hrs.			
Liquicell 2500	13%	87,059,020	ml/hr required for stover
PureVision Cellulase	82%	13,057,632	ml/hr required for stover
effectiveness multiple	6.43		

125	FPU/g protein	Liquicell 2500
731,295,772	liters/yr	Specialty
1.1000	S.G.	Enzymes
804,425,349	kg/yr	Inc.
193,062,084	gal/yr	
1,773,436,124	#/yr	
325,810	loads/yr	

0

cellulase storage tank
22,984 gal/hr
750,000 gal/vessel
33 vessel res. time (hr)
cellulase transfer pump
383 gpm

ASED ON PRODUCT SPECIFICATIONS PROVIDED BY SPECIALTY ENZYMES INC.

32	FPU/ml	Liquicell 2500
48,566,337	liters/yr	Specialty
1.1000	S.G.	Enzymes
53,422,971	kg/yr	Inc.
12,821,513	gal/yr	
117,776,282	#/yr	
21,637	loads/yr	

1

cellulase storage tank
14,021 gal/hr
750,000 gal/vessel
53 vessel res. time (hr)
cellulase transfer pump
234 gpm

ransport Calculations

10,000	lbs/axel		9.19	cellulase lb/gal
5	axels/truck		5,443	gal/truck
50,000	lbs/truck	$	0.413	**transport cost/lb**